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ABSTRACT

Designed and written for industrial arts instructors and students, this teacher-developed curriculum offers both a model for instructors and practical guidelines for classroom activities that explore the field of transportation. Various aspects of course design and delivery are covered in the introductory section, including course goals and objectives, student outcomes, curriculum format, instructor guidelines for organizing and composing student learning modules, a bibliography, and achievement forms. The remaining units deal with the following topics: transportation in the United States today; energy and power (fossil, solar, mechanical, chemical, and nuclear energy); the air transportation system (facilities, services, and vehicles); land transportation (the economic importance of land transportation, the history of land transportation, urban streets and thoroughfares, rural roads and highways, railroads, and pipelines and other conveyances); water transportation (inland waterways and ocean transportation); and prime movers (heat, combustion, Brayton cycle internal combustion, Stirling cycle external combustion, and Rankine cycle external combustion engines). Each unit contains the following: unit objectives, performance objectives; content outlines, teacher activities, student activities, references, resources, information sheets, transparency masters, and tests and test answers. Also covered in each unit are occupations associated with the given type of transportation examined. (MN)

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GENERAL INDUSTRIAL ARTS

Competency-Based Curriculum

in

TRANSPORTATION



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Nashville, Tennessee 37219

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tennessee industrial arts curriculum

* transportation



PREFACE: TRANSPORTATION

Children pedal bicycles and astronauts journey through space. This is the world of transportation, a very large system for moving people and things from one point to another. Each method of transportation is unique to the surface or space it travels, utilizing different sources and applications of power. This is an investigation into the man-made vehicles which move around us.

This curriculum has been designed and written for Industrial Arts instructors and students. It offers both a model for instruction and practical guidelines for classroom activities. It is a primer for exploration into the field of transportation.

These materials are intended to be used by both the novice and veteran instructor. Special attention has been given to format and content, compensating for differences in the instructor's previous knowledge and experience. Loose-leaf pages permit immediate revision and expansion so that instructors and students should find the materials easy and enjoyable to use.

Industrial Arts instructors in Tennessee developed this curriculum in three stages. First, a state-of-the-arts study was conducted to determine what had been published in Transportation curricula. Second, practiced instructors wrote the materials. Finally, students and instructors used the curriculum in their classrooms before it was revised and published. All of this required fourteen months, from research, writing and field testing, through revision.

On behalf of these instructors we hope you will join us on our trip through the transportation world. But this is only the beginning. We request comments and contributions to keep this curriculum growing and moving in the right direction.

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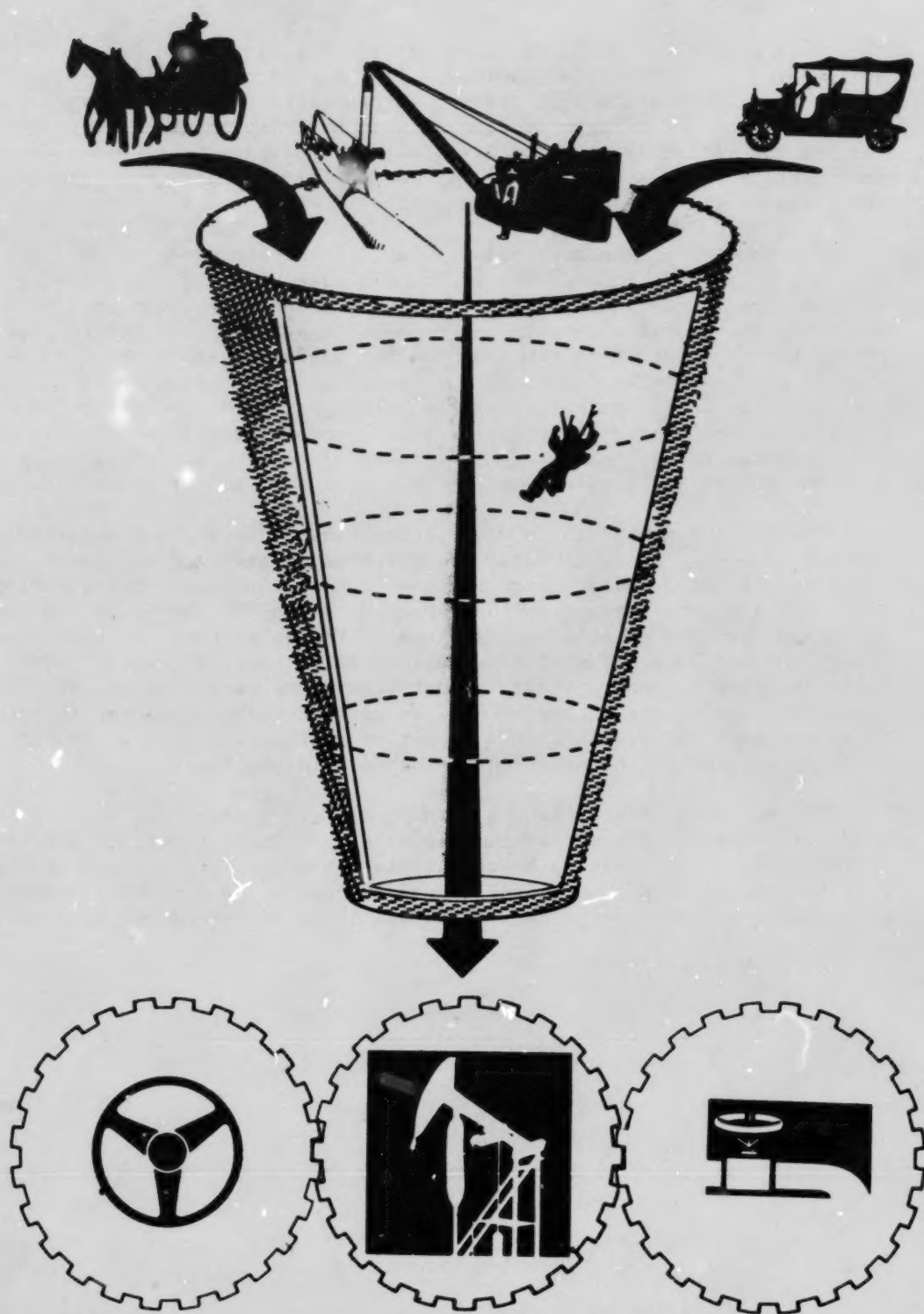
INTRODUCTION: TRANSPORTATION

This program is designed to assist individuals in the making of informed and meaningful occupational choices. In the exploration of the world of transportation students will develop an awareness of the industry and technology and the changes it brings to an evolving society. Application of the program will help students develop the technical competencies, concepts and basic skills which are common to the industrial-technical materials and processes of the transportation industry.

The content of the curriculum is structured analogous to an inverted cone. Starting at the top it offers a broad, circular panorama, an overview of the world of transportation. As the curriculum telescopes downward to the tip of the cone, the specific details and components--the subject matter--come into perspective. In addition the cone can be imagined as surrounded or enclosed in a netting or mesh--the functions and duties of the jobs in the field of transportation. As students traverse this cone, both across and through its diminishing diameters, their exploration becomes focused and the discoveries they make can be carried through the point of departure. The student leaves with the elementary knowledge and skills of the "cone" of transportation.

The subject matter is the curriculum: shape, weight and density to the general concept. It is divided into three major areas of transportation which exist in the world today. Each of these means or avenues of transportation is presented and investigated in the manner described in the preceding paragraph. Water and air, for example, are mediums of transportation, dictating vehicular design and mobility. The students are oriented to this concept before they build their first boat. Students must study a landscape before they decide how they will move across it and at what speed. The subject matter in each of the three sections is contained in a packet of units, each unit generating momentum which is applied and transferred to the next in the packet.

The world of transportation is a product of a creative industry, one which began with ideas. The curriculum explores the processes, tools and materials that allowed these ideas to become usable products. It is hoped that students will be able to develop the insight, understanding, and practical skills from different types of transportation so that their own ideas can be created.



PROGRAM GOALS AND OBJECTIVES: TRANSPORTATION

DEFINITION

Industrial Arts Education is that segment of the total educational program that is conceived and designed to interpret, humanize and make meaningful to all students the basic functions and concepts of industry and technology through a broad spectrum of experiences and activities with the materials, processes, and related problems of our industrial-technological society.

GOALS

To provide students with a variety of laboratory and classroom experiences with emphasis upon the orientation and exploration of the occupational cluster of Transportation.

To acquaint students with the principles of the common power sources and transportation devices used in our present technological society.

To allow for exploration in specialized and allied fields of power and transportation in order to develop an awareness of the existing occupational and educational opportunities.

OBJECTIVES

Develop an insight and understanding of industry, its place in our society, and the free enterprise system;

Discover and develop individual talents, aptitudes, interests, and potentials as related to industry and technology;

Develop an understanding of industrial processes and the practical application of scientific principles;

Develop basic skills in the proper use of common industrial tools, materials, and processes;

Develop problem-solving and creative abilities involving the materials, processes, and products of industry;

Develop an understanding of industrial and technological career opportunities and their requirements and develop those traits which will help students obtain and maintain employment.

Assist individuals in (a) the making of informed and meaningful occupational choices and (b) in preparing individuals for enrollment in advanced or highly skilled vocational and technical education programs.

SCOPE AND SEQUENCE

ELEMENTARY
INDUSTRIAL ARTS
ACTIVITIES

K-6

INDUSTRIAL ARTS CAREER CLUSTER AREAS

CONSTRUCTION

MANUFACTURING

TRANSPORTATION

COMMUNICATIONS

(Mini-Course Concept or Full Year Course)

GENERAL INDUSTRIAL ARTS

EXPLORING TECHNOLOGY

A multiple activity course consisting of elements
from each of the 4 CAREER CLUSTER AREAS.

INDUSTRIAL ARTS
PRE-TECHNICAL COURSES

- Ceramics Technology
- Drafting and Design
- Electricity / Electronics
- Plastics Technology
- Materials and Processes
- Crafts
- Graphic Arts
- Metal Technology
- Wood Technology
- Power Technology

TRADE AND INDUSTRIAL
COURSES

(Any of the various trade
preparatory courses)

POST SECONDARY

ENGINEERING
PROGRAMS

INDUSTRIAL
TECHNOLOGY
PROGRAMS

TECHNICAL
INSTITUTES

VOCATIONAL-
TECHNICAL
SCHOOLS

APPRENTICESHIP

ON-THE-JOB
TRAINING

STUDENT OUTCOMES

This curriculum has been written to bridge the gap between elementary school career education activities and high-school-level vocational education courses. It is one of four major career cluster curricula intended for use in Industrial Arts in the middle or junior high school (grades seven through ten). It provides career exploration and basic skill development through the multiple-activity approach of general Industrial Arts.

Industrial Arts programs are not intended to prepare students for employment in specific occupations. The emphasis is placed on short-term manipulative and exploratory experiences leading to an understanding of modern industry, its tools, processes and materials. Activities are designed to develop the students' awareness and interest in the many occupational possibilities open to them. The final outcome should allow individuals to make informed and meaningful occupational, consumer, and avocational choices.

But the transition from awareness and investigation to decision and choice requires articulation. The general nature of Industrial Arts and its position in the educational continuum should be followed by more specific occupational programs. This curriculum has been designed, in part, for student matriculation into trade and industrial and pre-technical courses and into various types of postsecondary training. This articulation can only be achieved if these options are available to students.

This curriculum is one of four tiers comprising the general Industrial Arts matrix shown on the following page. The purpose of this matrix is to illustrate the grade and career cluster relationship of Industrial Arts in Tennessee. Instructors are encouraged to block, by subject area, the time they spend teaching these curricula in the classroom. A mini-course schedule can be utilized in grades 7 and 8 ranging from 6 to 12 weeks. A complete course of study of 18 or 36 weeks is more suited for grades 9 to 10. Credit should be granted proportionally from 1/2 unit through 2 units for a one-year course. This matrix, appropriately completed, can be an aid to scheduling and to diagramming internal Industrial Arts articulation.

Every unit or module in this curriculum lists performance objectives or proficiency levels. These objectives were developed from the job duties detailed in the job structure and adopted to the philosophy of Industrial Arts. Student performance is therefore not geared towards employment competencies. The objectives do describe the tasks to be performed, the conditions under which they will be performed, and the standard of acceptable performance.

This curriculum provides pre-occupational exploratory experiences for students, leading not only to advanced vocational-technical education studies, but contributing to the students' avocational activities and consumer knowledge. The course map that follows is a graphic representation depicting the students' entrance and exit through this program.

ARTICULATION MATRIX

	Construction	Manufacturing	Transportation	Communications	
Grade 7 (1st year)					36 weeks (180 hours)
Grade 8 (2nd year)					36 weeks (180 hours)
Grade 9 (3rd year)					36 weeks (180 hours)
Grade 10 (4th year)					36 weeks (180 hours)

CURRICULUM FORMAT

There are four major sections in the Industrial Arts--Transportation curriculum. Each section is divided into units of instruction. (See the Course Map).

Transportation in the U.S. Today (IT)
 Energy and Power (EP)
 Air Transportation (AT)
 Land Transportation (LT)
 Water Transportation (WT)
 Prime Movers (PM)

The order in which these sections are presented is at the discretion of the individual instructor. The sections can be taught as they are or used in conjunction with the instructor's own instructional materials.

This curriculum has been designed for one year or 180 hours of instruction. Each section can be used on a 9 or 12 week basis.

Each unit of instruction is divided into the following parts:

Description of Unit
 Unit Objective
 Performance Objectives
 Outline of Content
 Teacher Activities
 Student Activities
 References/Resources
 Information Sheets
 Transparency Masters
 Teacher Demonstration Sheets
 Student Assignment Sheets
 Student Activity Sheets
 Unit Test(s)
 Answers to Test(s)
 Equipment/Supplies

Following each section in the curriculum is a comprehensive Job Structure (JS). This can be used when instructing from the Outline of Content or performing Activities.

Every unit has a self-contained numbering system, and each unit begins with page number one. The pages are numbered consecutively except for the Transparency Masters, which are numbered separately in upper right hand corner.

The objectives listed at the beginning of each unit are measured either by a student assignment, by a student activity, or by a test. Answers are provided for all of the assignments and tests. The minimum acceptable performance levels for assignments, activities and tests are to be determined by the instructor. Also, the point or grade values for these evaluation instruments are to be established by the instructor.

T 8

The Individual Student Achievement Records and the Class Competency/Progress Record should be separated from this introductory section and reproduced for use in the classroom.

The Division of Vocational-Technical Education would appreciate your evaluations and comments as you utilize this curriculum for Industrial Arts--Communications.

Industrial Arts
212 Cordell Hull Building
Nashville, Tennessee 37219

COURSE MAP: TRANSPORTATION

Transportation in the U.S. Today

1. Introduction

Energy and Power

1. Introduction to Energy
2. Fossil Energy
3. Solar Energy
4. Power (Mechanical Energy)
5. Chemical Energy
6. Nuclear Energy

Land Transportation

1. Introduction to Land Transportation
2. Economics Importance of Land Trans.
3. History of Land Transportation
4. Rural Roads and Highways
5. Railroads
6. Pipelines and Other Conveyances

Air Transportation

1. Overall View of Air Trans.
2. Facilities
3. Services
4. Vehicles

Water Transportation

1. History, Current Technology, and Future of Water Transportation
2. Inland Waterways
3. Ocean Transportation

Prime Movers

1. Heat Engines
2. Otto Cycle Internal Combustion Engines
3. Brayton Cycle Internal Combustion Engines
4. Stirling Cycle External Combustion Engines
5. Rankine Cycle External Combustion Engines

**INSTRUCTORS'S GUIDELINE FOR ORGANIZING
AND COMPOSING STUDENT MODULES.**

The Instructor's Guide for this curriculum contains all of the materials needed to form a Student Module. Extract, duplicate, collate and staple from each unit the pages listed below.

Discription of Unit
Unit Objective
Performance Objective
Student Activities
References/Resources (optional)
Information Sheet
Assignment Sheet
Student Activity Sheets
Unit Test(s)

Pre-Test/Post-Test *
Job Structure *

* These items follow each section in the curriculum. They may be reproduced and distributed separate from individual units.

SUGGESTED PAPER COLOR CODE
FOR REPRODUCING STUDENT MODULES

White

Unit Objective
Description of Unit
Performance Objective
Outline of Content
Teacher Activities
Student Activities
References/Resources
Transparency Masters

Green

Information Sheets

Buff

Demonstration Sheets

Brown

Assignment Sheets
Student Activity Sheets

Yellow (canary)

Test(s)

Pink

Answers to Test(s)

Cherry

Equipment/Supplies

Blue

Job Sheets

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Stenographer

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James Branch
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Robert Long
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Nancy Brown
Memphis

Joseph Stophel
Bluff City

Allen Craig
Powell

William Suggs
Memphis

James Fitch
Dyersburg

Robert Wolle
Brighton

Don Houston
Union City

James Yadon
Germantown

REVIEW TEAM

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Greeneville

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Nashville

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Knoxville

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Walters State Community College
Morristown

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Cordell Hull Building
Nashville

Harry Smith
Tennessee Technological
University
Cookeville

Guy Kirk
Huntingdon

I. G. Smith
Davidson Co. Board of Education
Nashville

Edward Mann
Memphis State University
Memphis

Hubert Stuckey
Georgetown

FIELD TEST PARTICIPANTS

Richard Bell
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Oak Ridge

Joseph Hicks
Boones Creek Middle School
Jonesboro

Rex Miller
Greenville Middle School
Greenville

Thomas Chambliss
Goodlettsville High
School
Goodlettsville

Robert Johnson
Tyner Junior High
Chattanooga

Gerald S. Pryor
Cookeville Junior High
Cookeville

Robert A. Crutcher
Goodlettsville High
School
Goodlettsville

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Memphis

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Hardin County Jr. High
School
Savannah

Johnny Davis
Chattanooga High School
Chattanooga

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Central High School
Columbia

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Neely's Bend Junior
High
Madison

Ralph Ford
Parkway Jr. High School
Jackson

Scott Leech
Dalewood Junior High
Chattanooga

Don Sadler
Algood Junior High
Algood

Dale Grissom
Upperman High
Baxter

William E. Locke
Fayetteville Jr. High
Fayetteville

Robert Swartz
Lamar School
Jonesboro

Arnold L. Groff
Clinton Jr. High
Clinton

Edward McBroom
Oakhaven High
Memphis

Richard Wren
Fairview High School
Fairview

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NOTE: All of the citations listed above are on file at the Tennessee State Department of Education Media Center, Smyrna, Tennessee. This bibliography does not include all of the references contained in this curriculum.

STUDENT ACHIEVEMENT RECORD

Student's Name _____

Instructor's Name _____

Grade Level _____

Name of School _____

SECTION ENERGY AND POWER

Pre-Test _____

Post-Test _____

UNITS	STUDENT ASSIGNMENTS/ACTIVITIES																UNIT TEST	FINAL GRADE
1. Introduction to Energy																		
2. Fossil Energy																		
3. Solar Energy																		
4. Power (Mechanical Energy)																		
5. Chemical Energy																		
6. Nuclear Energy																		

STUDENT ACHIEVEMENT RECORD

Student's Name _____

Instructor's Name _____

Grade Level _____

Name of School _____

SECTION AIR

Pre-Test _____

Post-Test _____

UNITS	STUDENT ASSIGNMENTS/ACTIVITIES																UNIT TEST	FINAL GRADE
Transportation in the U.S. Today (Introduction)																		
1. Overall view of the Air Trans. System																		
2. Facilities																		
3. Services																		
4. Vehicles																		

STUDENT ACHIEVEMENT RECORD

Student's Name _____

Instructor's Name _____

Grade Level _____

Name of School _____

SECTION _____ LAND _____

Pre-Test _____

Post-Test _____

UNITS	STUDENT ASSIGNMENTS/ACTIVITIES												UNIT TEST	FINAL GRADE
Transportation in the U.S. Today (Introduction)														
1. Introduction to Land Transportation														
2. Economic Importance of Land Trans.														
3. History of Land Transportation														
4. Urban Streets and Thoroughfares														
5. Rural Roads and Highways														
6. Railroads														
7. Pipeline and Other Conveyances														

STUDENT ACHIEVEMENT RECORD

Student's Name _____

Instructor's Name _____

Grade Level _____

Name of School _____

SECTION WATER

Pre-Test _____

Post-Test _____

UNITS	STUDENT ASSIGNMENTS/ACTIVITIES												UNIT TEST	FINAL GRADE
Transportation in the U.S. Today (Introduction)														
1. History, Current Technology, and Future of Water Transportation														
2. Inland Waterways														
3. Ocean Transportation														

STUDENT ACHIEVEMENT RECORD

Student's Name _____

Instructor's Name _____

Grade Level _____

Name of School _____

SECTION PRIME MOVERS

Pre-Test _____

Post-Test _____

UNITS	STUDENT ASSIGNMENTS/ACTIVITIES																UNIT TEST	FINAL GRADE
1. Heat Engines																		
2. Otto Cycle Internal Combustion Engines																		
3. Brayton Cycle Internal Combustion Engines																		
4. Stirling Cycle External Combustion Engine																		
5. Rankine Cycle External Combustion Engines																		

CLASS COMPETENCY/PROGRESS RECORD

Instructor's Name _____

Transportation:

Name of School _____

SECTION	ENERGY/POWER
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CLASS COMPETENCY/PROGRESS RECORD

Instructor's Name _____

Transportation:

Name of School

SECTION AIR

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CLASS COMPETENCY/PROGRESS RECORD

Instructor's Name _____

Transportation:

Name of School _____

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CLASS COMPETENCY/PROGRESS RECORD

Instructor's Name _____

Communications:

Name of School _____

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TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

TRANSPORTATION IN THE U.S. TODAY

Title of Unit:

INTRODUCTION

DESCRIPTION OF UNIT

This unit will point out the scope and size of all aspects of transportation in the United States specifically and, to some extent, in the world.

UNIT OBJECTIVES

After completion of this unit the student will be able to identify and describe the main types (systems) of transportation currently used in the United States and also in other parts of the world.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. List the 5 major administrative divisions in the U.S. Department of Transportation.
2. Discuss the main contributions of each of the major transportation systems in use as the U. S. developed as a nation and expanded its technology in transportation.
3. Identify different uses of each of the transportation systems today.
4. Discuss some jobs/careers that are available in transportation.

OUTLINE OF CONTENT

- I. Introduction (Information Sheet #1)
- II. Department of Transportation (TM #1)
 - A. Coast Guard
 - B. Federal Aviation Administration
 - C. Federal Highway Administration
 - D. Federal Railroad Administration
 - E. St. Lawrence Seaway
- III. Transportation Systems in Use Today (Information Sheet #2)
 - A. Highways (TM #2) used in early development and at present
 - B. Inland Waterways (TM #3) Used in Early Development and at Present.
 - C. Railroads (TM #4) Used in 1800's To Develop the West—Now Used Mainly For Freight—Not People. AMTRAC uses railroad system.
 - D. Ocean Trade Routes (TM #5) Having Freedom to Use Oceans in Very Important to Our Economy (i.e., oil)
 - E. Air Travel Routes
 - F. Pipelines Systems
 - 1. Crude oil (TM #6)
 - 2. Natural gas (TM #7)

TEACHER ACTIVITIES

1. Provide students with student module
2. Make transparencies
3. Discuss unit and specific performance objectives
4. Discuss topic using outline of content as a guide and use TM's and information sheets as needed
5. Discuss student activity sheets
6. Plan one or more local field trips to local:
 - a. Airports
 - b. Bus depot
 - c. Truck freight company
 - d. Railroad station/terminal
 - e. Automobile/truck/motorcycle dealer and/or service place
 - f. Marine dealer
 - g. Factories that manufacture or assemble all or part of any of the various means of transportation
7. Have a representative from a local transportation business, or travel agency come to class and talk to students
8. Obtain and show films on travel and/or transportation
9. Review material presented and discussed
10. Give test

STUDENT ACTIVITIES

1. Read objective sheet and unit and performance objectives.
2. Study information sheets and take notes from lecture(s).
3. Complete activity sheet.
4. Take field trip(s).
5. Take test.

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RESOURCES

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State Department of Education, Stillwater, Oklahoma 74074, "Career Exploration--Transportation Cluster."

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I. Introduction

Transportation is a very big and very important industry in the United States today. Almost everything we use in our daily lives is delivered to us by one or more transportation systems.

Transportation is so important that our government has a Department of Transportation with five major divisions (TM #1). They are Coast Guard, Aviation, Highway, Railroad, and St. Lawrence Seaway. For purposes of this study, transportation systems will be divided into land, water, and air/space systems. Billions of dollars are spent each year by our federal government on transportation in each of these areas.

Settlers first came to this country in ships across the oceans. Upon landing they moved inland following Indian trails and streams. Trails later developed into roads and in 1958 construction on the Interstate Highway System was started. (TM #2). Waterways continue to be important today. (TM #3). The Tennessee Valley Authority (TVA) has constructed many dams for flood control and these also improved inland waterways. In addition to using rivers and streams many canals have been constructed.

Railroads were very important in helping settle the western United States and in uniting the country during the 1800's. Today our country is literally covered by railroad track networks. (TM #4).

Since America does not have all of the resources it needs, we have to import these from countries all over the world. The most economical way to transport them to the United States is by ocean freights. Over the years, trade routes have been established with other countries of the world. (TM #5).

Air transportation has perhaps made the most advances since the Wright brothers first successful powered flight in 1904. The United States landed man on the moon in 1969. In addition to commercial airlines the U. S. today there are thousands of private and military aircraft flying across the country.

The largest oil companies have constructed many crude oil (TM #6) and natural gas (TM #7) pipelines that criss-cross the United States.

If you would place all the waterways, highways, pipelines, and airline routes in a single map of the United States you would see that transportation systems cover the United States from coast to coast and border to border.

Transportation In Tennessee

by Mark Owan
NPC Correspondent

The role that transportation has had in the growth and development of cities, beginning with waterborne transportation, is well known. Even today many cities are located near rivers and waterways.

Later the railroad became a prime factor in city development, and in the 20th century highways and air transportation significantly influenced the growth and pattern of cities.

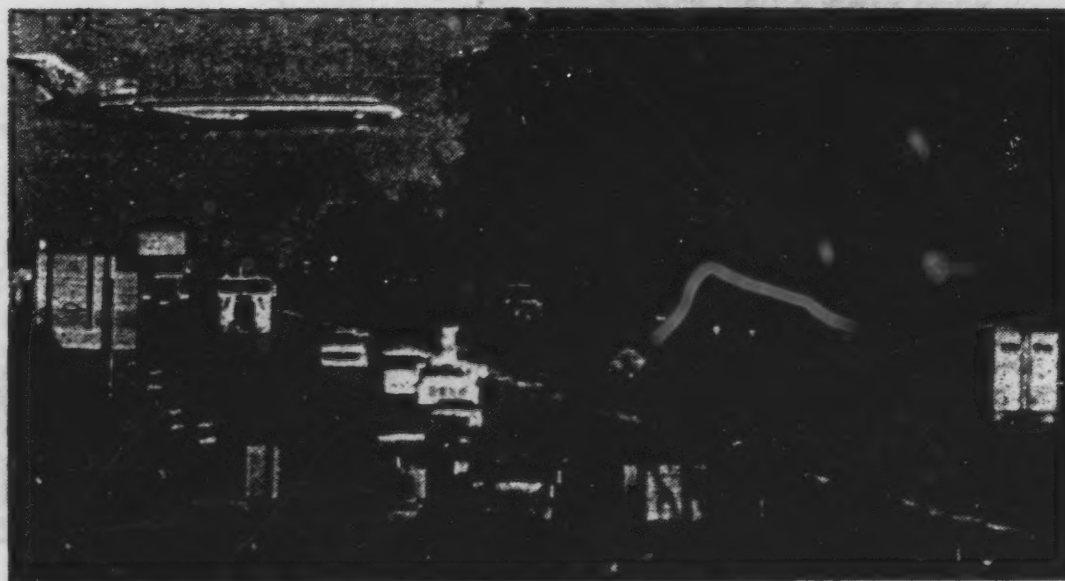
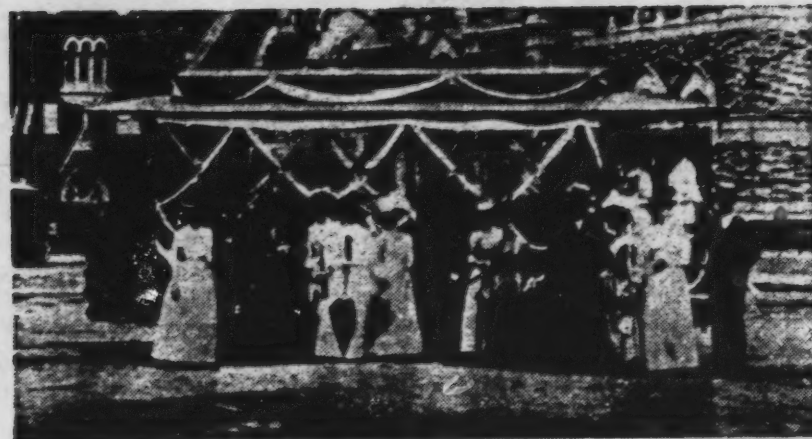
Transportation in all modes and means would not have been possible without the continuing effort of engineers. Whether designing roads and bridges or developing a more efficient jet engine, their work has played and will continue to play a vital role in the growth of our country.

The Indian and wagon trails of the 18th century and the stage and toll roads of the 19th century have given way to a complex system of roads and highways in Tennessee. Currently the Tennessee Department of Transportation oversees more than 82,000 miles of roadway.

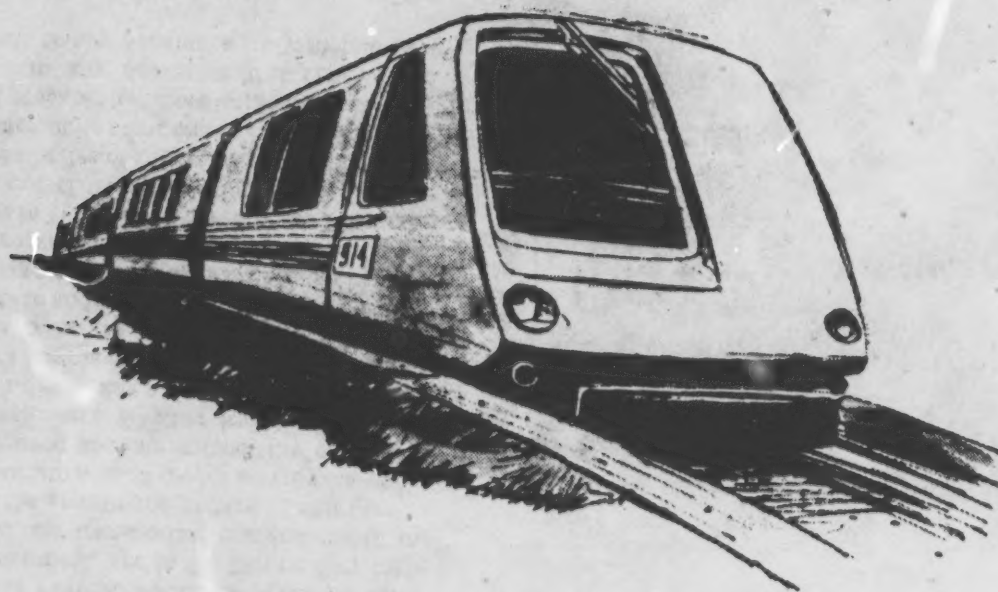
The automobile came on the scene in the early 1900's. It probably had more influence on our way of life than any device of this century for Americans finally became a truly mobile people.

Demanding new and better highways, dirt roads became paved and a network of highways started to take shape.

Past...



Present...



...And Future

In 1956 the Federal Aid Highway Act was passed by Congress. This national program provided a funding mechanism for construction of an interstate system. The government contributes 90% of the necessary funds to each states' 10%. But as the concrete ribbons grew, so did problems, especially in the '70's.

Increased congestion, increasing air and sound pollution, and escalating costs of finite petroleum products plus the building and maintaining of highways are all factors engineers have to face daily.

Perhaps the biggest problem here, however, lies in the shortage of available funds. The Highway Department receives monies primarily from an eight cent per gallon tax on gasoline. In the 50's

and 60's traffic and revenues both grew equally.

But ever since the oil embargo in 1973 fuel consumption leveled off. This led to more fuel efficient vehicles on the road, and traffic increased at a decreasing rate. Consequently the department has not been able to keep pace with highway needs because of the lack of funds.

Also, since inflation has affected the price of fuel as well as labor costs, maintenance and construction costs have enlarged substantially. In the past, this department worked more on developing major projects. Now, they are more concerned with maintenance on existing systems.

"We've learned a lot from past experience," says Bill Wallace, Deputy Director of Research

and Planning. "We're making the interstates and other roads much safer now." Safety features include longer acceleration and deceleration lanes, more auto skid surfaces and new guard rail design features.

In order to save energy, there will be solar assisted water and space heating at visitor centers such as the one located near the Kentucky border on Interstate 24. Also there will probably be a change from mercury vapor highway lights to a high pressure sodium system which would cut the amount of expanded energy in half.

Beginning with the horsedrawn omnibus on city streets and the later improved version with steelwheels on steel rails, public transportation moved into its hey day with the electrically powered streetcars first introduced in the late 1800's. In 1880 Nashville was one of the first cities in the nation to operate electric street cars.

But the advent of the automobile saw a gradual decline in public transportation. Autos and gasoline were inexpensive, road systems were improved and enlarged, and there wasn't a visible need for public transportation. Also, unwillingness to adopt innovation plus restrictive franchise rules curtailed growth in this industry.

However Nashville's switch from street cars to buses in 1941 was a step towards more progressive mass transit. City bus use reached an apex during the years of WWII, but with the boom in prosperity after the war, ridership dropped sharply.

It wasn't until the last decade that there was a resurgence in public transit. Traffic congestion, economic vitality, mobility for the carless and energy conservation are just a few reasons why public transit has blossomed.

In 1973, Nashville metropolitan government bought the privately owned transit system (now called Metropolitan Transit Authority) and started purchasing fleets of new buses. Today there are 150 buses in operation and it's the most modern system in the state.

"Our biggest problem now is cost to maintain the system," states Mel Baird, Director of Public Transit. "Although ridership increased about 10% last year over '78, the cost of diesel fuel increased 62%."

"It's inevitable that we're going to have more and better service because more people are riding now. We're earnestly trying to provide more service during peak hours of operation."

The bureau also assists local government and transit operations in planning, developing, and operating scores of other forms of public transportation. Examples include special services for the elderly and handicapped.

As advocates of carpooling, vanpooling and other such energy saving methods, they conduct extensive surveys and offer fuel and parking reform measures. Because of an assortment of reasons already mentioned as well as increasing urban sprawl, buses will continue to serve the public.

It's very possible in the near future to see designated express lanes exclusively for buses and cars with three or more riders.

Ever since John Donelson guided his fleet of boats up the Cumberland River in 1780, the use of waterways in Middle Tennessee has been an important source of transportation for industry.

Steam boats chugging along the river in the 1800's carried both passenger and cargo. However towards the middle of the century traffic

decreased in some areas due to the building of railroads.

The Nashville and Chattanooga Railroad was chartered in 1845 and was the first railroad of consequence to be completed in Tennessee. Railroads continued their domination as the key method of hauling freight until the 1920's.

But increased growth of highways and the trucking industry plus overly burdensome ICC regulations caused a decline in rail transportation until recently.

The Federal Government is attempting to deregulate the railroad system, and this will allow more flexibility in rates and increased efficiency in line operations. This means the railroads will operate more akin to a free enterprise system and in turn, there will be more competition among trucks, railroads, and waterways (barges).

For example, four truck loads of freight fit into a railroad car, and 15 railroad cars of freight fit into a barge. Therefore 1 barge of material can eliminate the use of 60 trucks on the road.

However, traveling by barge is slower and can't be used for products such as perishables. And obviously barges are confined to waterways. But the possibility of combining modes to compliment each other is inviting.

This same sort of process could be used here in Tennessee, especially on the Tennessee-Tombigbee Waterway. Once the "Tom-Big" is completed, probably in 1986, there will be a direct connection between the Tennessee River and the Gulf of Mexico—something businessmen and engineers have been dreaming about for centuries.

This will shorten the present water distance between these points by as much as 800 miles. The

latest projection is that 28 million tons of material will move the first year of operation at a savings of \$91,000,000 per year.

The "Ten-Tom" will make a significant contribution in solving the nation's worsening energy shortage by providing a shorter and cheaper route for shipping coal, petroleum, and other fuels as well as fostering industrial and recreational growth in many areas.

The newest mode of transportation, air travel, really got off the ground in 1937 when state law set up a separate commission for aeronautics. This bureau encourages aeronautical development and assists in the establishment of airports, air navigational facilities and intrastate commuter airline services.

It acts as an agent for the 67 publicly owned general aviation airports and provides supervision, technical consultation and so on.

There has been a surge in the growth of private twin-engine business airplanes. Apparently Tennesseans feel time is more important than ever and maximization of time can be accomplished through air travel.

The long range trends in transportation are dependent upon changes in population and the economy, energy availability and technical achievement. Today in this country the average person travels about 10 times as many miles in a lifetime as did his or her grandfather, and an estimated 25 times as many miles as did the average person in 1900.

There is now an overwhelming indication that unless there are changes in transportation modes and means, we may soon reach a mobility and industrial zenithpoint—if we haven't already. Those changes will come about and are being developed by engineers.

DEPARTMENT OF TRANSPORTATION

APPROVED: *[Signature]*
SECRETARY

October 18, 1967

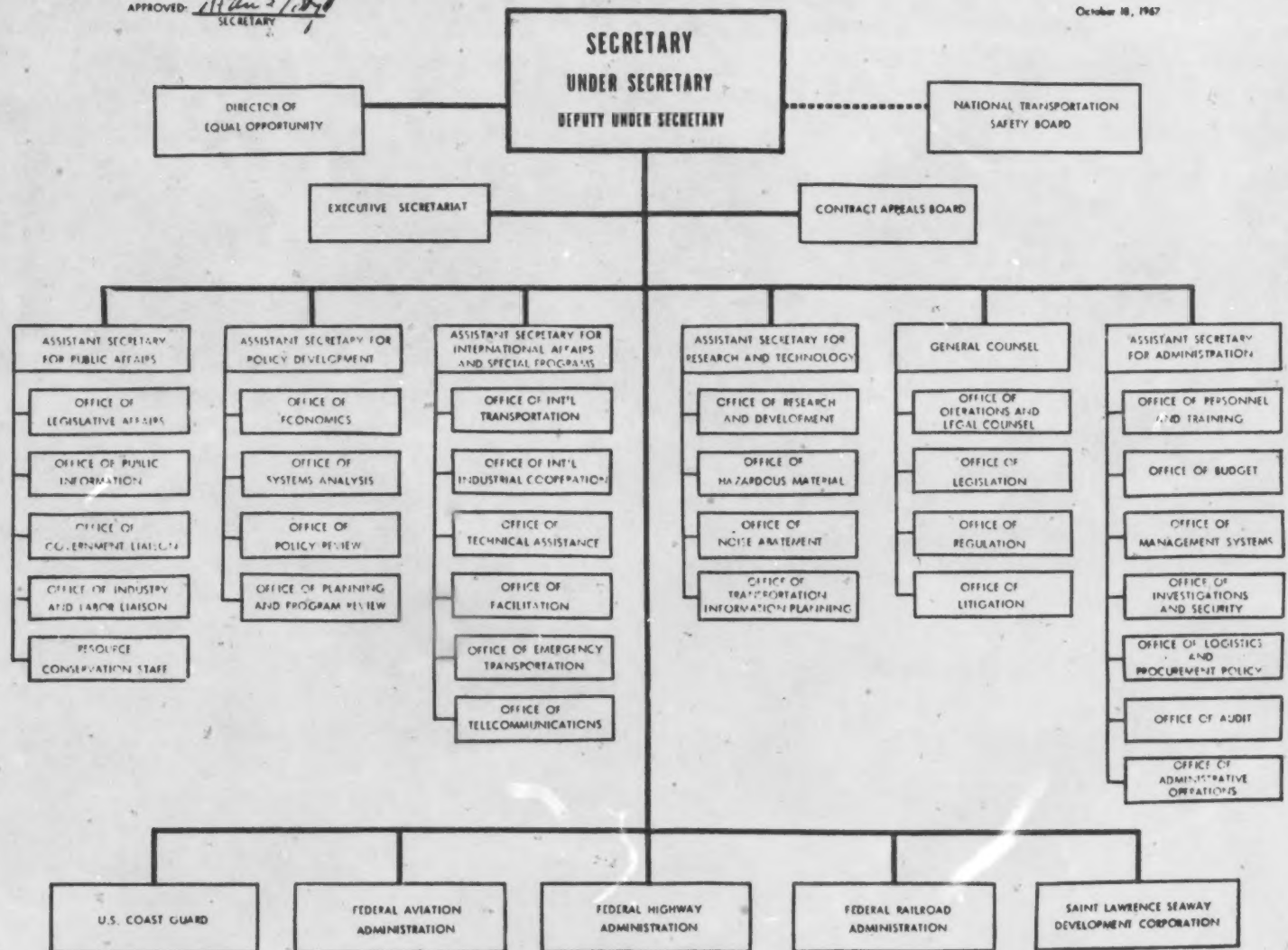
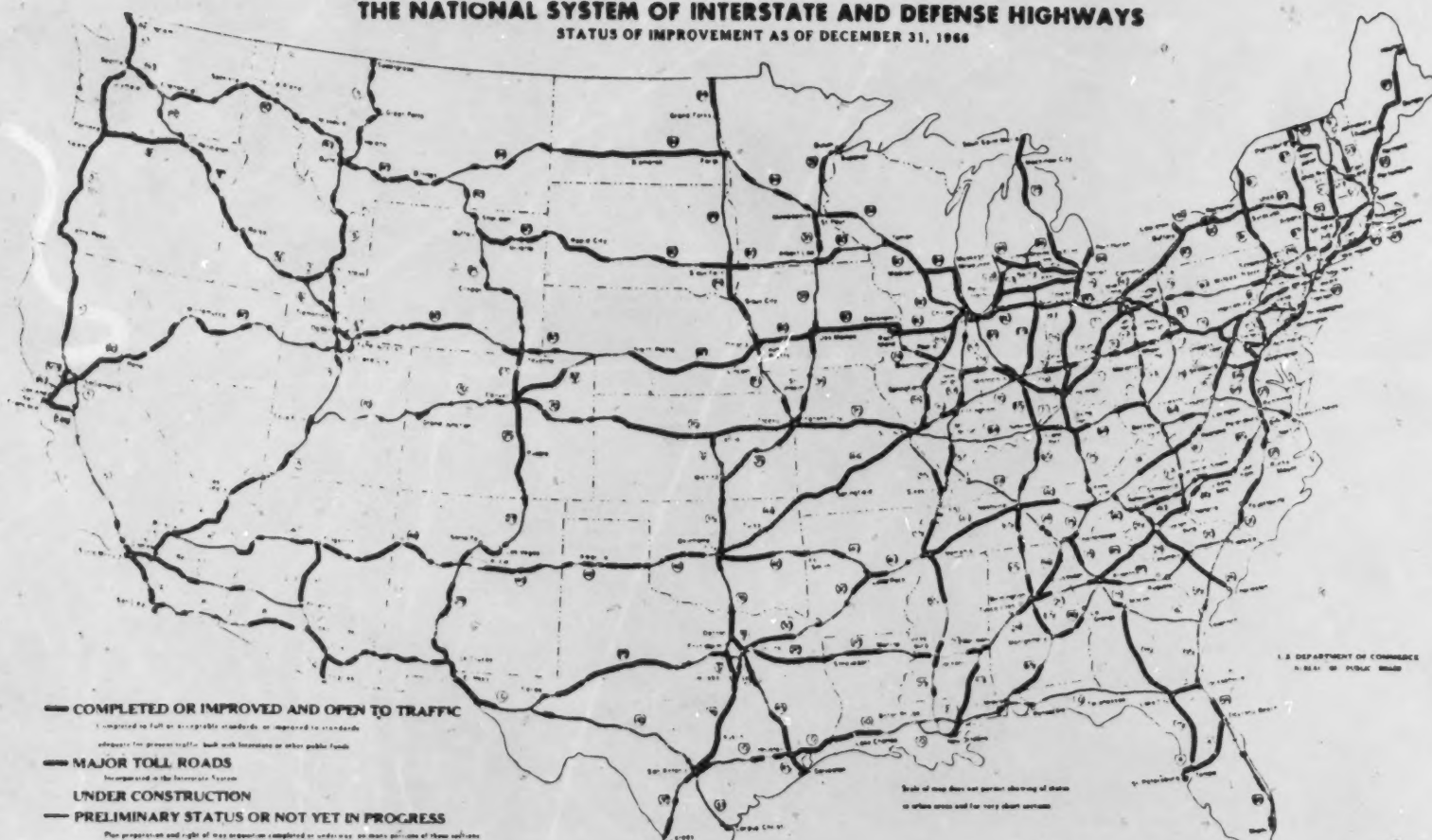


Figure 14. Department of Transportation.

THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

STATUS OF IMPROVEMENT AS OF DECEMBER 31, 1966



Preliminary Status or Not Yet in Progress	Engineering and Right-of-Way in Progress	Under Construction	Open to Traffic
1,579 Miles	10,292 Miles	5,653 Miles	23,476 Miles

29,129 Miles

INTERSTATE
TOTAL
41,000
MILES

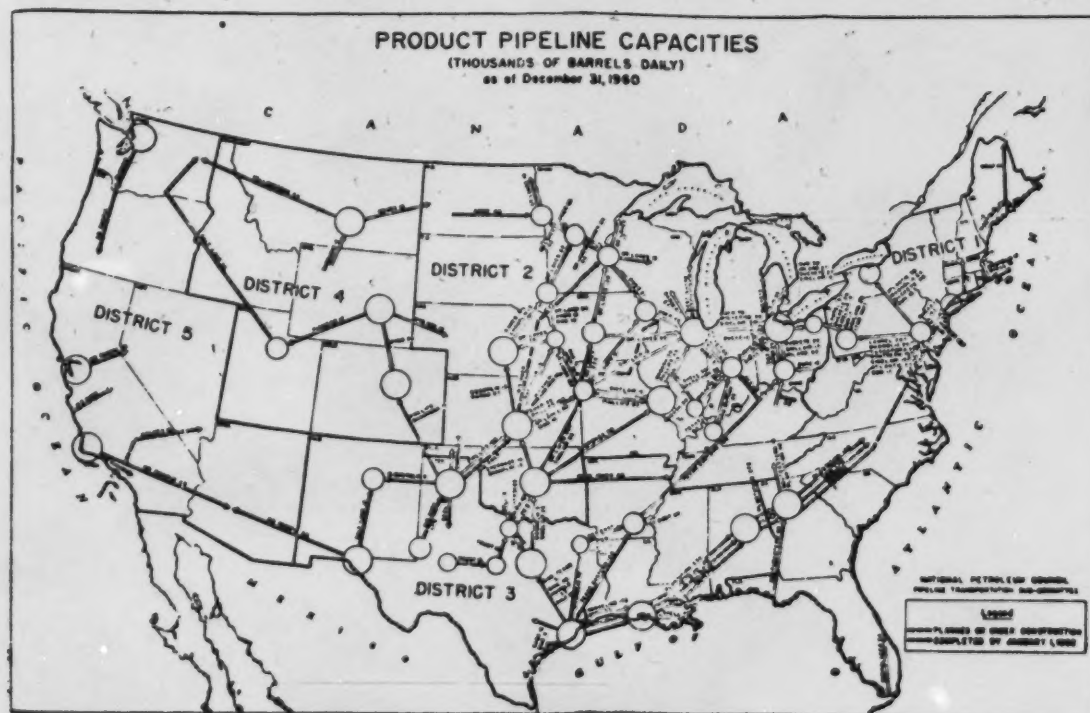
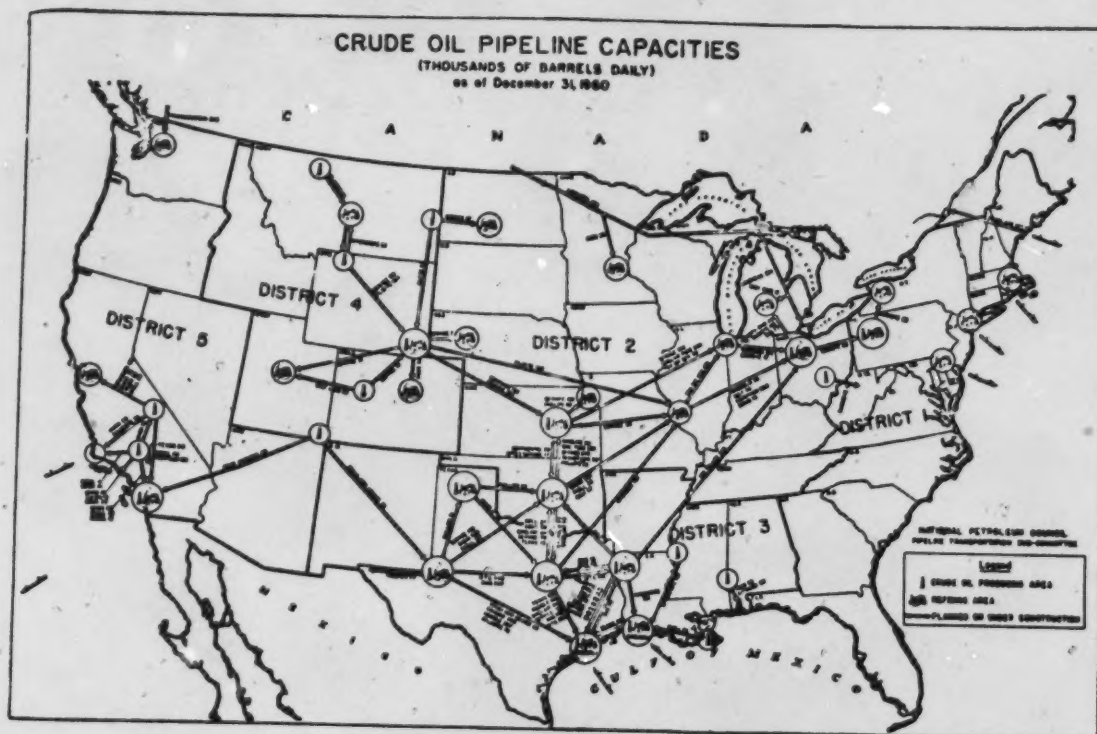
The National system of interstate and defense highways.





The Nation's railroad net.





Student Activity #1

DIRECTIONS:

Listed below are names of things/people that/who could be moved by different types of transportation. Select four (4) items and make a list of the different types of transportation that could be used to transport these things/people from the place mentioned to Tennessee:

- | | |
|-------------------------------------|--------------------------------------|
| 1. Lettuce from California | 10. Oil from the Gulf of Mexico |
| 2. Toyota automobile from Japan | 11. Oil from Saudi Arabia |
| 3. Grain from North Dakota | 12. Natural gas from Texas |
| 4. Coal from Kentucky | 13. A farm tractor from Canada |
| 5. Iron ore from Minnesota | 14. Milk from the farm to your table |
| 6. Your grandmother from WS | 15. Lumber from Washington State |
| 7. A package from your cousin in NY | 16. Potatoes from Idaho |
| 8. A letter from Nebraska | 17. Peanuts from Georgia |
| 9. Oranges from Florida | |

Prepare a list to turn in to the instructor or for class discussion.

DIRECTIONS:

Listed below are different jobs/careers in transportation. Pick one you think that would be interesting and find out as much information about it as you can. What does it pay? What skills does it require? What are the working conditions? How much schooling or training does it require?

SOURCES

Ask your parents, friends, neighbors, or someone you know that has a job in transportation. Also, any library should have information on these jobs. Your school guidance counselor may also have information available for you.

JOBS/CAREERS

Airplane pilot (commercial)	Bulk milk truck driver
River tug pilot	Airplane maintenance
Truck driver	Marine dealer
Ship captain	Bus driver
Truck terminal worker	Automobile dealer
River/canal lock operator	Automobile mechanic
Airport controller	Motorcycle dealer
Dock worker	Motorcycle repairperson
Railroad engineer	Lift-bridge operator
Railroad lineman	Boat-dock operator
Railroad stationkeeper	Highway maintenance person
Ship engineering officer	Highway construction person
Ship cargo officer	Heavy equipment operator
Military jet pilot	Ocean terminal director
Aircraft navigator	Others

Write information on paper to turn in to instructor or to discuss in class.

SUGGESTED TEST

List the five (5) major divisions in the U.S. Department of Transportation:

1.

2.

3.

4.

Place in order (by numbering) the types/systems of transportation used to aid the development of the United States:

_____ air

_____ ocean

_____ inland waterways

_____ highways, roads, trails

_____ railroads

_____ pipelines

TEST ANSWERS

1. Coast Guard
2. Federal Aviation Administration
3. Federal Highway Administration
4. Federal Railroad Administration
5. St. Lawrence Seaway

5 air

1 ocean

2 inland waterways

3 highways, roads, trails

4 railroads

6 pipelines

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

ENERGY AND POWER

Title of Unit:

INTRODUCTION TO ENERGY

DESCRIPTION OF UNIT

This unit will cover the basic concepts of energy and provide a general overview of energy. The many forms of energy will be introduced to provide an understanding of both potential energy and kinetic energy. The various forms include: heat or thermal energy; light or photonic energy; sound or sonic energy; mechanical or movement (of mass) energy; chemical or chemical fuel energy; electric or electron movement energy; and nuclear or atomic energy.

The conversion of one form of energy into another form of energy is basic to understanding not only energy but power, transportation and much of our present day technological society. This materials in this unit are designed for 5 hours of instruction.

UNIT OBJECTIVES

After completion of this unit the student will be able to explain both potential energy and kinetic energy, give examples of several forms of potential energy and several forms of kinetic energy, and give examples of the conversion of one energy form into other energy forms.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Take Pre-Post Test. (To be compared at the end of the Unit on Energy and Power.)

EP 1.2

4. Orally or in writing define kinetic energy.
5. List at least six forms of energy.
6. Complete the evaluation sheet which gives the conversion of one form of energy into another form.
7. Complete the student activity #2. Conversion of energy in an automobile.
8. Complete the student activity #3. Work the energy crossword puzzle.
9. Explain graph on changing fuel sources in U.S.

OUTLINE OF CONTENT

I. Definition of Energy

The technical definition of energy is "energy is the ability to do work". No real scientific definition is available.

II. States of Energy

- A. Potential Energy--The scientific definition of potential energy is "The energy a body has due to its position, its condition, or its chemical state. Examples are: position; water behind a dam. Condition: a bow and arrow fully flexed. Chemical state; fossil fuels or acids and alkaline substances. Potential energy is measured in the same way work is measured. Potential energy is in effect stored up work.
Potential energy = Force x Distance

- B. Kinetic Energy--The scientific definition of kinetic energy is: the energy released by a body due to its position, its condition or its chemical state. Examples are: position; water discharged through a turbine at the bottom of a dam; condition, the flight of an arrow as it leaves the bow string; chemical state, the burning of gasoline in an engine to produce heat and motion or the flow of electrons from a battery or cell through a light bulb. Kinetic energy is energy in motion or energy in action. It is energy doing something. It is potential energy released and put to work.

The formula is the same as work

$$\begin{array}{l} \text{Kinetic Energy} = \text{Force} \times \text{Distance} \text{ or} \\ \text{Work} \quad \quad \quad = \text{Force} \times \text{Distance} \end{array}$$

Where force is in lbs. and distance is in feet a 10 pound force exerted through a distance of 5 feet = $W = F \times D$

$$W = 10 \text{ lbs.} \times 5'$$

$$W = 50 \text{ ft. lbs.}$$

III. The laws of energy and thermodynamics.

These laws state several things about energy and matter.

- A. The law of the conservation of energy: The simplest definition of this law is "Energy cannot be created or destroyed". This means energy in any state or form must always exist in some state or form. Energy may be transformed: that is energy may be changed from one state to another such as potential energy into kinetic energy. A weight at the top of a building (potential energy) may be dropped to the ground below (kinetic energy). To perform useful work it could be used to drive a piling or water pump point as a pile driver.

B. The law of equilibrium--This law simply states that "The energy is a closed system (not acted upon by an outside force) and will tend towards a state of equilibrium or uniform distribution of the energy in the system. Simply put, it means that it will run down.

C. The law of action

1. An object tends to remain in a state of rest or motion until acted upon by an outside force.
2. The change which any force makes in motion depends upon the size of the force and the mass of the object. Example: You push an automobile from a static position on level ground. The two things which determine how fast the car will be traveling in any given length of time is: How hard is the push (force) and how much the car weighs (mass).
3. Newton's 3rd law of motion--"For every action there is an equal and opposite reaction." This is the principle of the jet engine and the rocket engine. The toy balloon illustrates this law or principle very well. The equal pressure inside the balloon is released (the action) through the opening at one end. The balloon moves in the opposite direction from the opening (reaction) because the pressure is not in balance (it is greater at the end opposite the opening).

IV. The Forms of Energy

There are at least seven forms of energy. Three of these forms are rather constant or present forms. They are: motion, heat and light. Energy in the form of sound, chemical, electric and nuclear are also available forms. These forms can be and often are converted into one or more of the other forms. This is especially true when energy is used to do work.

A. Heat energy--Technically called "thermal energy" is the energy most often used in the manufacture and transportation of goods. The energy may be derived from all other sources. Thermal energy may also be described as the molecular movement or oscillation of molecules. (See the conversion chart for details.)

B. Light energy--Sometimes called photon energy. The moving particle or photon has energy which is released when the photon strikes matter.

Note: The electromagnetic spectrum also includes many different wave length particles and rays other than visible light. Example: Infrared--the most common source of heat from sunlight.

- C. Sound energy--Sonic energy, the energy of sound is the mechanical motion or vibrations of molecules. Sound exists in a wide band both below and above the sounds we can hear or audio frequency sound waves.
- D. Mechanical energy--The energy of movement especially of mass. Mechanical energy is used daily in many ways to produce and transport goods and materials.
- E. Chemical energy--Chemical energy is the energy we get by burning fuel or using chemicals to produce heat or electron flow.
- F. Electric energy--Electric energy or the flow of electrons. The use of moving electrons to produce light, heat and motion is common in our mobile society. We use electric energy in many ways in our homes and automobiles.
- G. Nuclear energy--The source of nuclear energy is the energy which results when atoms are split apart or combined. The newest source of energy man has developed.

IV. Energy Application for Transportation

TEACHER ACTIVITIES

1. The teacher will provide the student with the student module and go over module to answer any questions.
2. The teacher will make transparencies using transparencies provided.
3. The teacher will administer the Pre-Post Test at the beginning of the first class period on energy.
4. The teacher will discuss the unit on energy and explain the specific objective.
5. The teacher will lecture the class using the transparencies and resource materials. Note: One class period will be required.
6. The teacher will provide the student with student activity sheet #1.
7. The teacher will have students compare activity (activity sheet #1) with other students.
8. The teacher will provide the students with activity sheet #2. (Energy conversion)
9. The teacher will provide students with activity sheet #3. (Cross-word puzzle)
10. The teacher will provide the student with activity sheet #4. (Energy conversion in an auto)
11. The teacher will give quiz on energy.
12. Optional--The teacher will explain and help students perform Activity #5. (Energy content of wood) Transparency #2.

STUDENT ACTIVITIES

1. Take the Pre-Post Test.
2. Read the objectives and ask any questions needed to clarify the objectives.
3. Take notes on lecture and presentation of classroom materials.
4. Study the information sheet.
5. Perform Student Activity #1 (energy conversion).
6. Compare activity sheets with other students.
7. The students will perform Activity #3, the crossword puzzle.
8. Do Student Activity #2 (energy conversion).
9. Compare Activity #2 with other students.
10. Perform Activity #4 (energy conversion in auto).
11. Take quiz on energy.
12. Optional--Group activity on Activity #5 (energy content of wood).

REFERENCES/RESOURCES

References:

1. Chapin, D.M., Energy from the Sun, Bell Telephone Labs, Baltimore, MD: Waverly Press, 1965. (Out of print)
2. Oak Ridge Associated Universities, Science Activities in Energy-Solar II, The American Museum of Science & Energy, Oak Ridge, TN: Oak Ridge Asso. University.
3. Walker, John R., Exploring Power Technology, South Holland, Ill: Goodheart-Wilcox Company, 1976.
4. Cook, Earl, Man, Energy, Society, San Francisco, Ca.: W.H. Freeman and Co., 1976.
5. Geil, John J. and Johnson, Stephen, Energy and Transportation: Industry and Careers, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
6. Geil, John J., Energy and Transportation: Power, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
7. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
8. Worthington, Robert M., Margules, Morton and Crouse, William, General Power Mechanics, New York: McGraw-Hill Book Co., 1968.

Resources:

1. Information Sheets
2. Transparency Masters
3. Activity Sheets
4. Demonstration Sheets

Terms and Definitions

1. Energy--The ability to do work.
2. Potential energy--Stored energy.
3. Kinetic energy--Energy in motion.
4. Thermal energy--Heat energy.
5. Photonic energy--Photons or light energy.
6. Sonic energy--Sound energy.
7. Mechanical energy--The energy of movement.
8. Chemical energy--Fuel or acid or base (alkaline energy).
9. Electric energy--Electron energy or the flow of electrons.
10. Nuclear energy--Atomic energy--The energy of fusion or fusion of atoms.
11. Energy form--There are seven forms of energy. They are: heat, light, sound, mechanical, chemical, nuclear and electric.
12. Wind energy--Force of air moving (mechanical) caused by sun heating surface of earth.
13. Energy measurement--energy may be measured in many ways depending upon its form.
 - a. Light--Candle power, lumens, wavelength.
 - b. Sound--Decibels (frequency), frequency
 - c. Electric--Volts, amps, watts, cycles.
 - d. Chemical--Caloric content, BTU, therms.
 - e. Mechanical--Speed, mass.
 - f. Nuclear--Watts, roentgens.

ENERGY APPLICATION

I. Energy into Power

- A. Potential energy into kinetic energy
- B. Kinetic energy into work
- C. Work as a way of defining transportation

II. Conservation of Energy

- A. Transportation of any material or vehicle
- B. Energy must be added to any system such as car, train, motor-cycle, etc.

III. Laws of Action

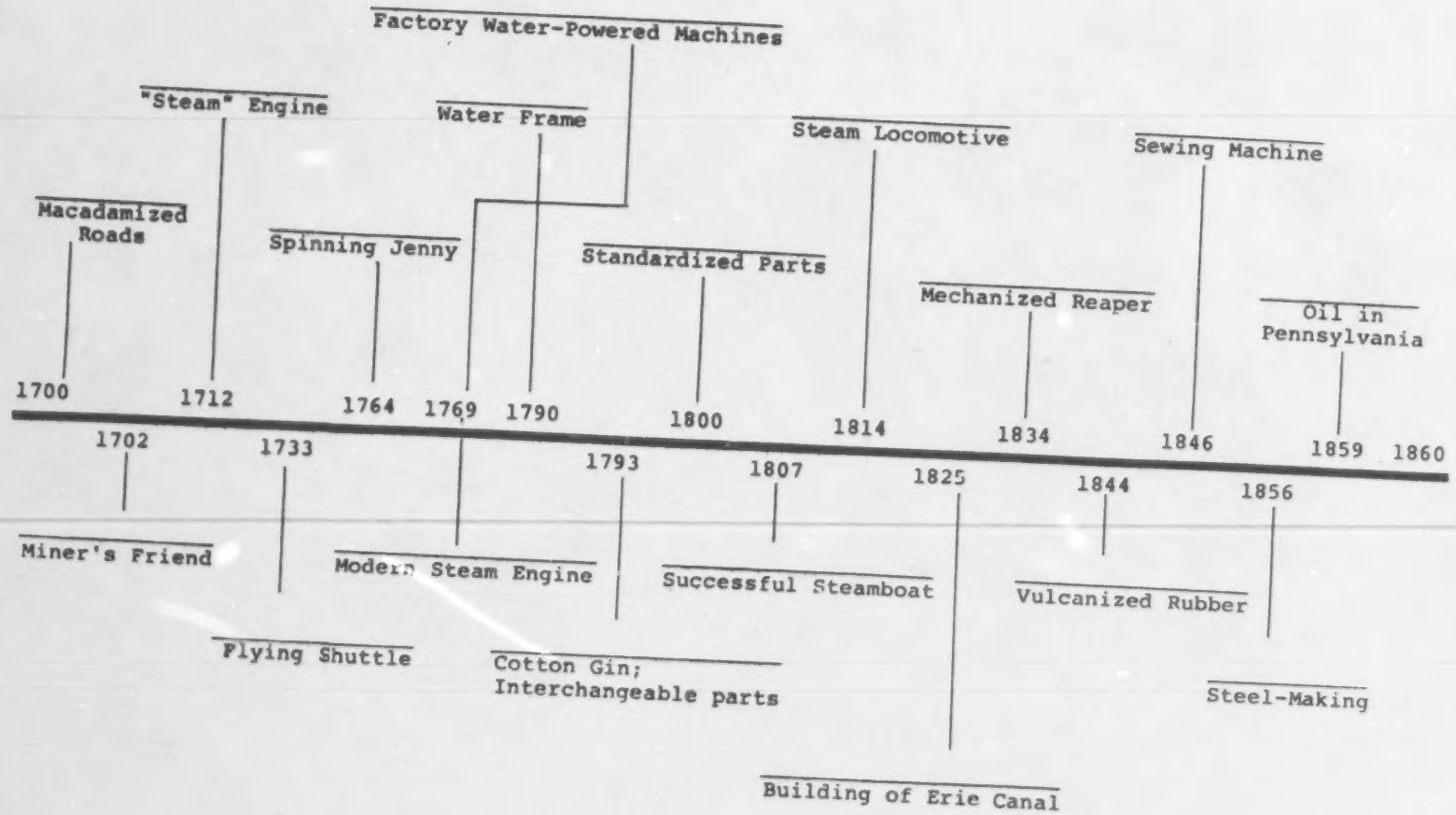
- A. Energy is used to move an object
- B. How quickly an object such as an automobile moves depends upon two things: its mass and the power of its engine.
- C. When energy is expended it produces an action; there is always an equal and opposite reaction. This is the principle of the jet aircraft.

IV. Forms of Energy

- A. Heat energy--The most common form of engines are heat engines used to power all forms of vehicles.
- B. Light energy--Only a very few "light engines" have been developed. These are called "Photon engines" and are used in space. Light energy is useful in transportation as an aid--headlights, lamps, etc.
- C. Sound energy--No true sound engine has been developed. Sound energy is more a result of such engines as heat engines.
- D. Mechanical energy--The energy of movement. Transportation of any material or object involves mechanical energy. Mechanical energy is the result of or final stage of heat engine.
- E. Chemical energy--Transportation is very dependent upon chemical energy. Fuel used to produce heat which in turn develops movement is the most common method of transportation in the world today.

- F. Electric energy--Electric energy is used to drive many commuter trains, trolleys and buses. Electric cars which use chemical batteries to produce electricity are increasing.
- G. Nuclear energy--Nuclear energy is used primarily to produce heat (steam) to drive turbine to produce electricity. Many military ships use nuclear energy. Submarines and the largest aircraft carriers use nuclear "engines". (These are steam driven turbines very much like the turbines used to produce electricity.)

THE INDUSTRIAL REVOLUTION 1700 - 1860



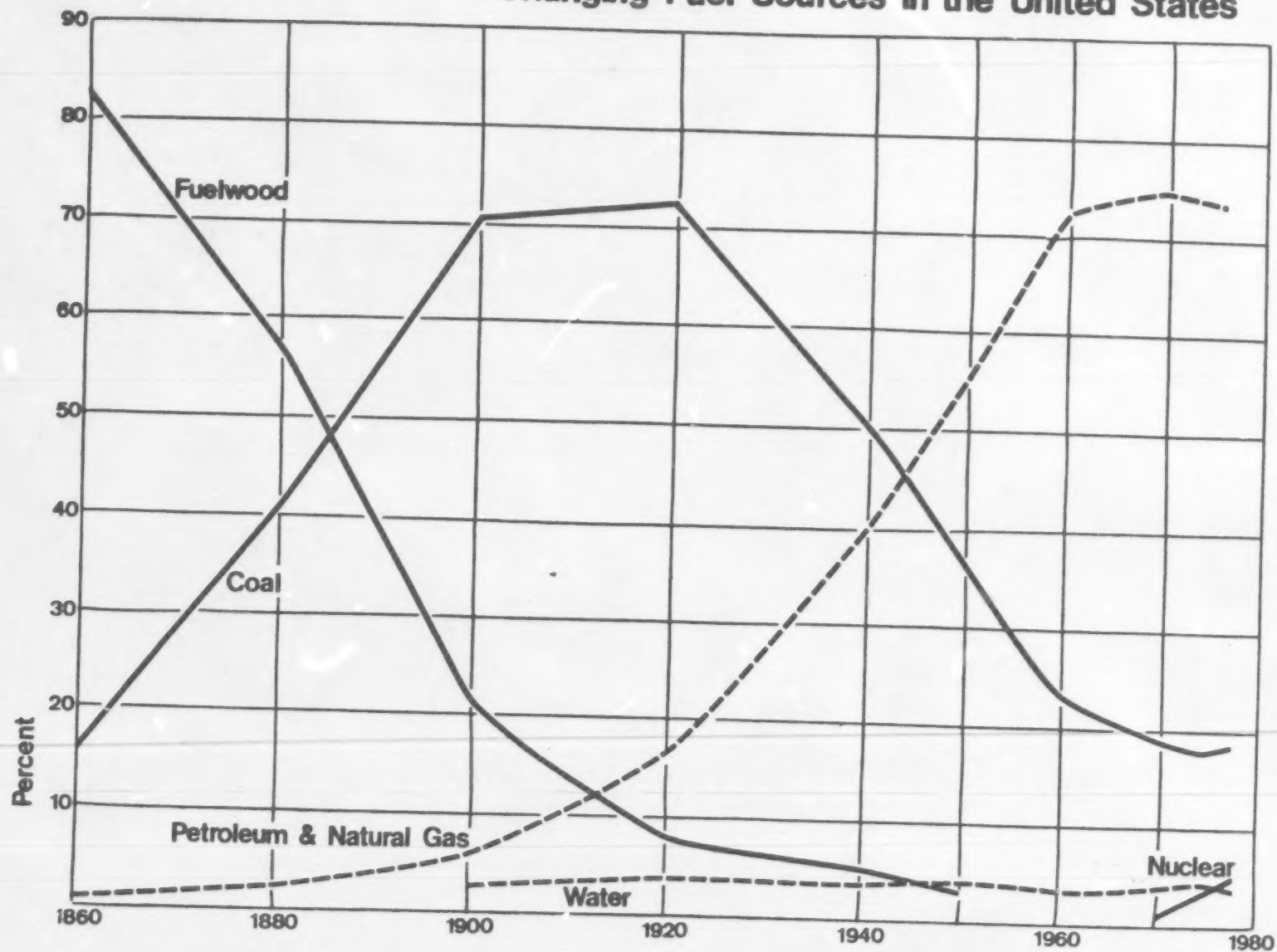
SOURCES AND USES OF U.S. ENERGY

Energy Sources*		Uses*	
Domestic petroleum	27.0%	Production of electricity	Energy consumed in generation and transmission of electricity
Imported petroleum	11.0%		Heat, light, residential, and commercial
Coal	20.2%		Mining and manufacturing processes
Domestic natural gas	35.0%	All other uses	Vehicle fuel (all types)
Imported natural gas	2.0%	Export	Export
Nuclear	0.7%		Petrochemicals, etc.
Hydro	4.0%		Waste: (loss due to inefficiency etc. almost 50%)
Other	0.1%		

* All figures approximate

Source: *National Geographic*, November 1972, pp. 662-63.

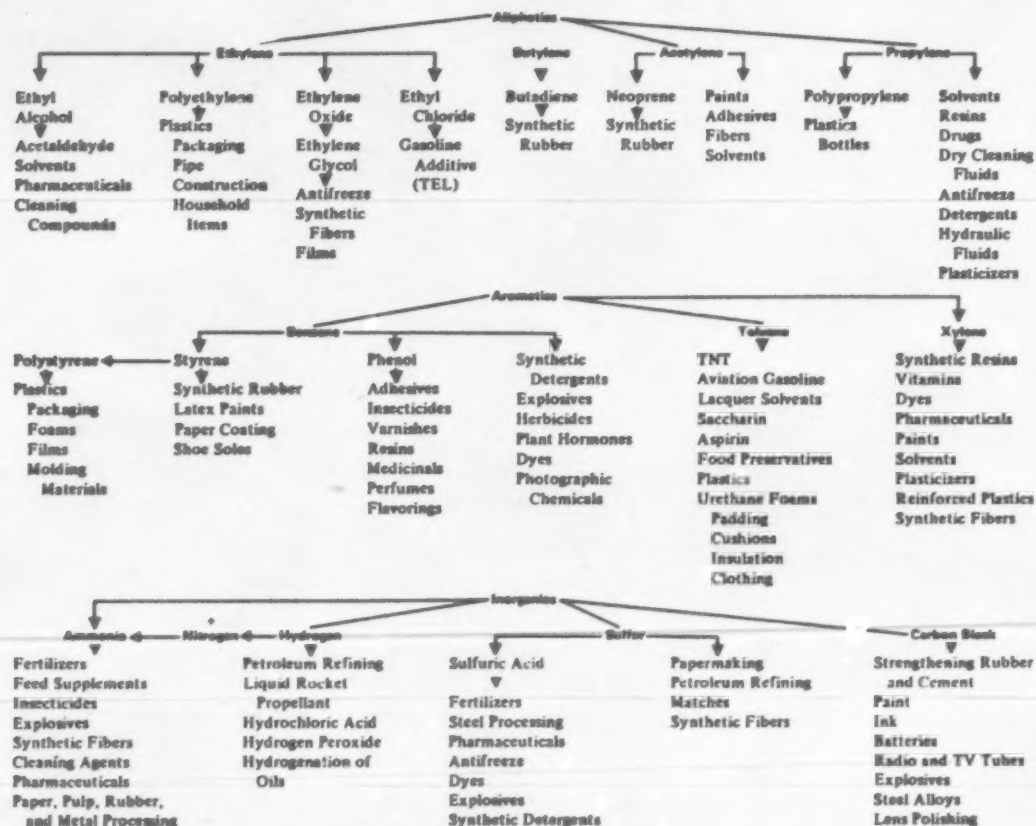
Changing Fuel Sources in the United States

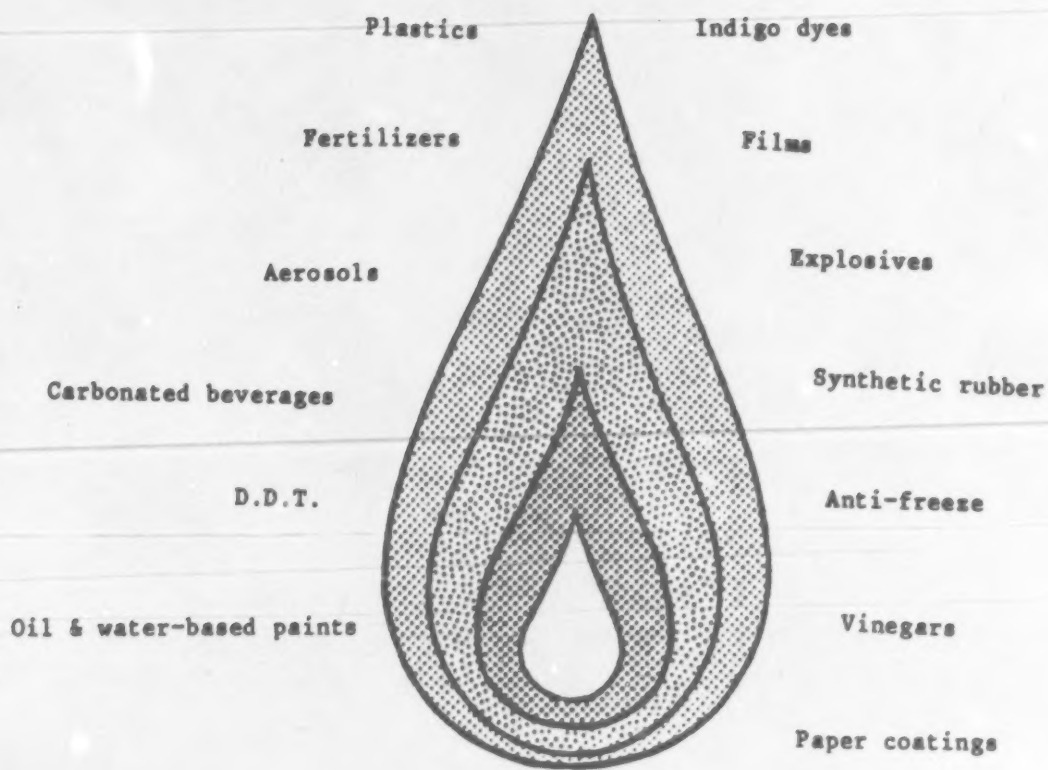


Data from: Energy in Focus: Basic Data. (Washington, DC: Federal Energy Administration) 1977.

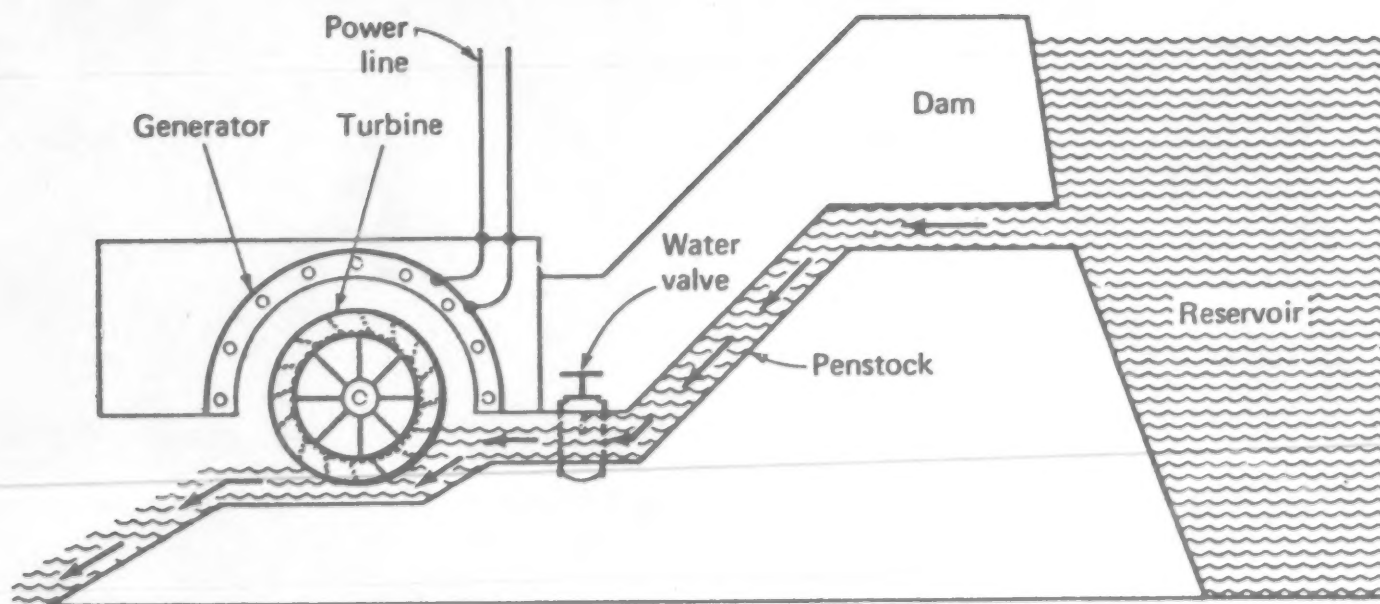
Monthly Energy Review. (Washington, DC: Department of Energy) 1978.

THE PETROCHEMICAL FAMILY TREE

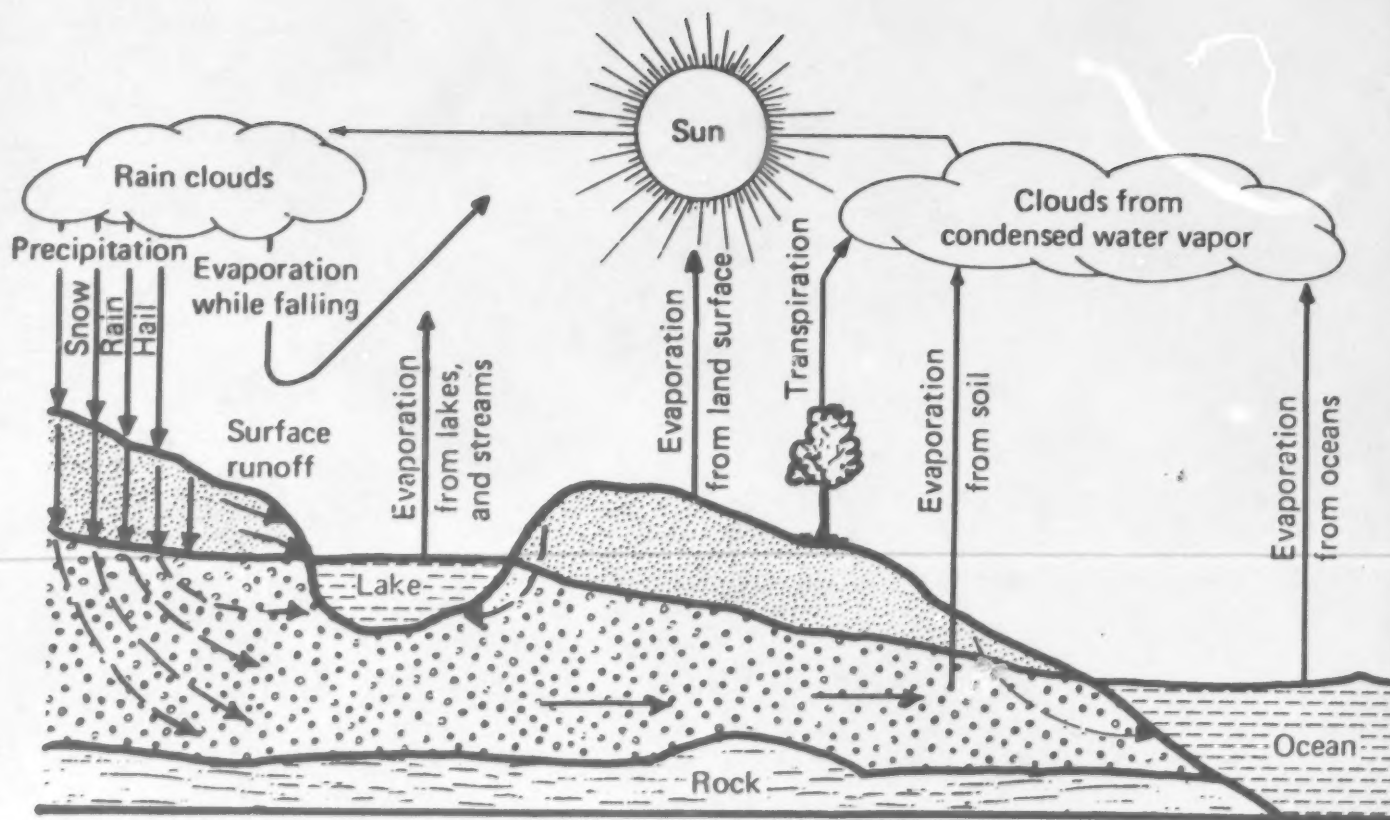




Natural gas is the source of many products.

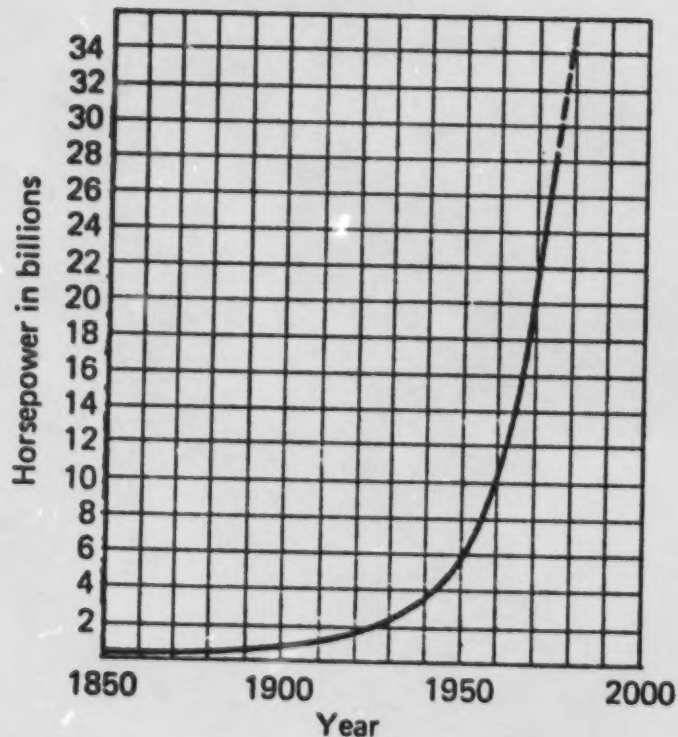


Water from a reservoir flows through penstocks to turn turbines which are connected to electric generators.

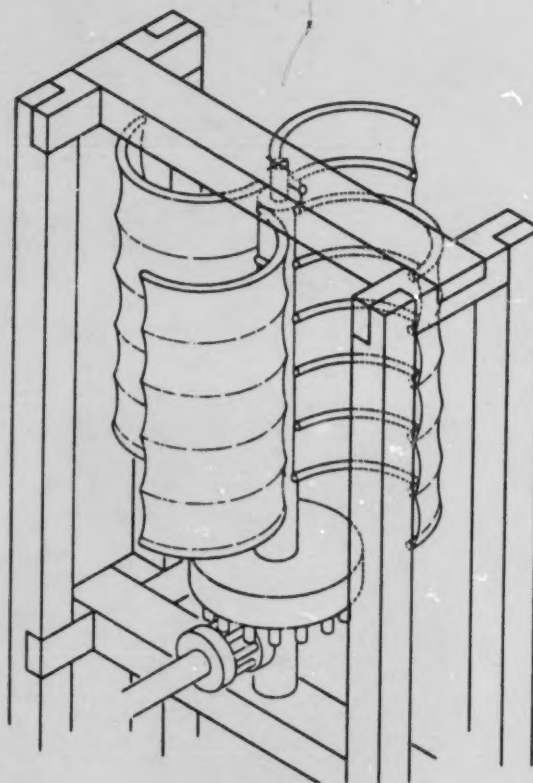


Energy and Transportation Today

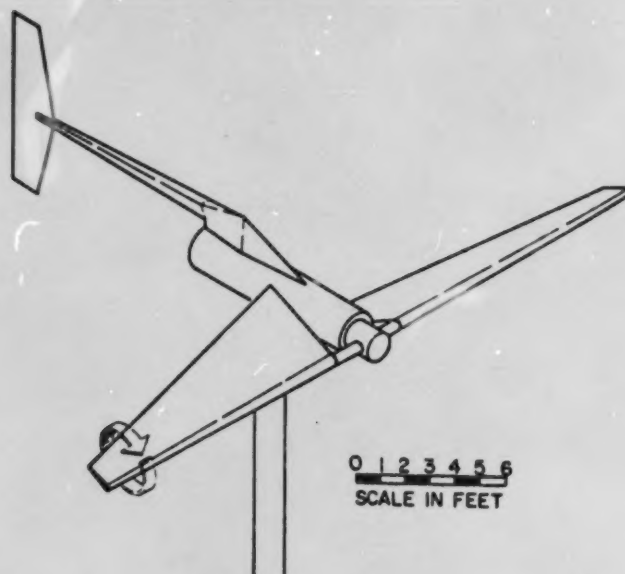
In 1850, only 8,500,000 horsepower was produced in the United States. By 1900, the figure had reached 65,045,000. By 1950, 4,747,871,000. By 1970, 21,862,000,000. This astounding increase is shown graphically



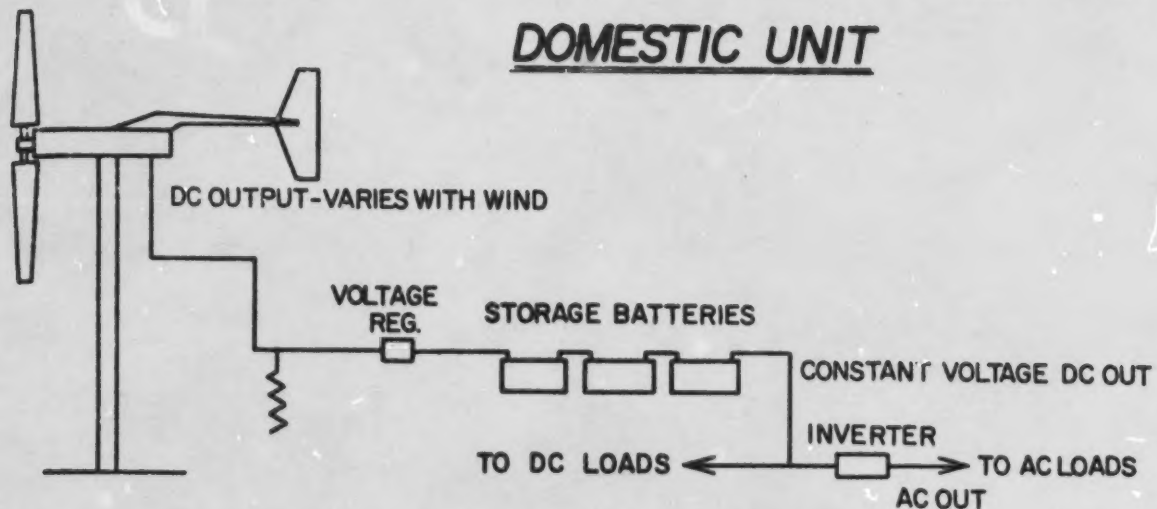
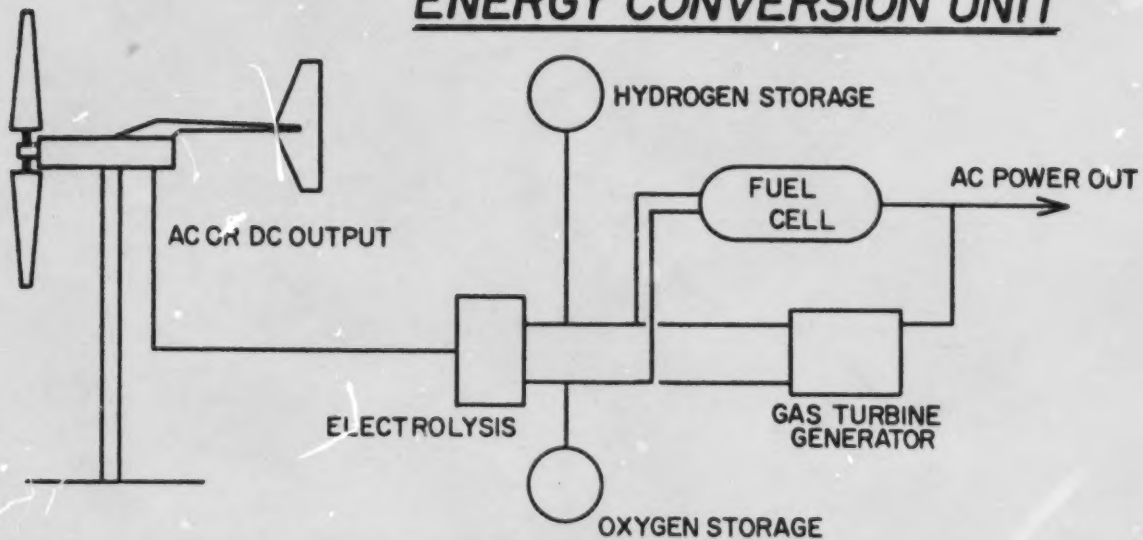
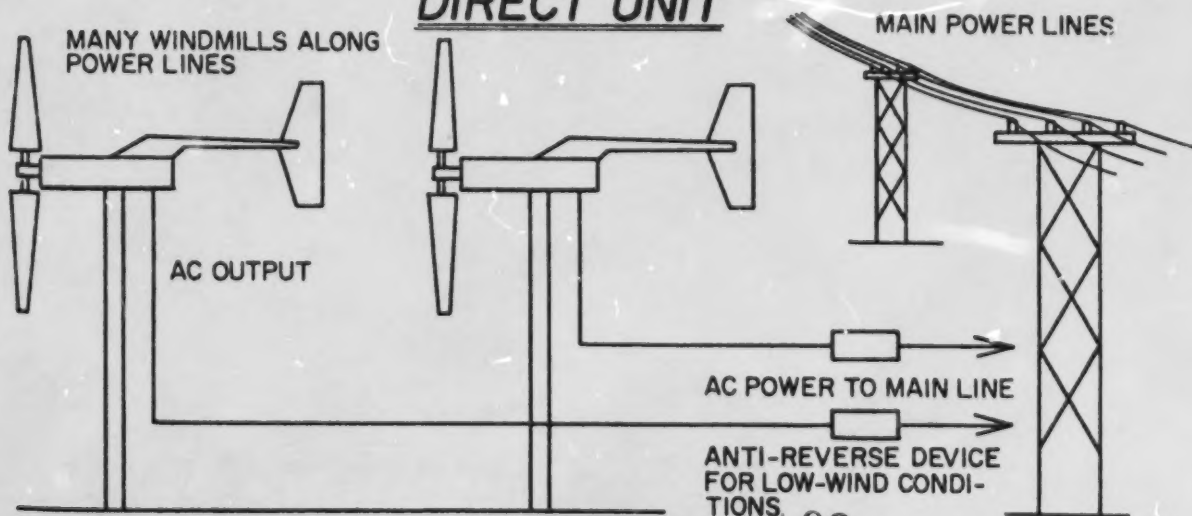
This graph shows the rapid increase of horsepower production in the United States. The dotted line shows the increase expected in the future.



Note that the blades on this early Persian windmill are on a horizontal plane. Windmills of this type were found in many parts of the world.



Many new techniques such as this modern version of the old fashioned windmill are being developed to utilize wind power to generate electricity.

DOMESTIC UNIT**ENERGY CONVERSION UNIT****DIRECT UNIT**

Evaluation Sheet

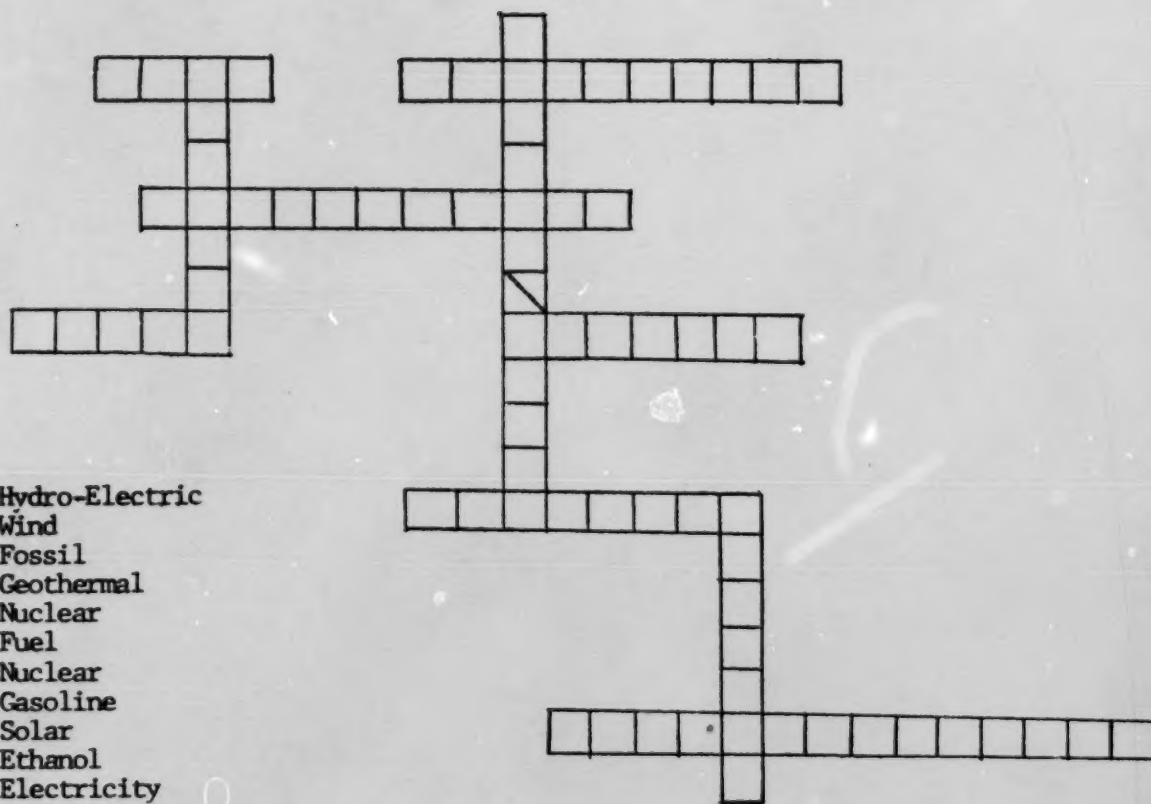
Directions: Write in each box examples of one form of energy being converted into another form. Begin with the vertical column on the left. Example: Heat is converted into light energy in a light bulb, so write "light bulb" in the box formed by the intersection of the two energy forms.

	HEAT	LIGHT	SOUND	MECHANICAL (Movement)	CHEMICAL	ELECTRIC	NUCLEAR
HEAT		light bulb fire electric arc	explosions	steam turbine	disassociation of water or other molecules	thermionic effects	nuclear reactions in stars
LIGHT	infra red absorption			light pressure photoelectric effect	photosynthesis other photo- chemical reactions	solar cell, other photo- voltaic effects	
SOUND	sound eventually dissipates as heat	sound con- verted to mod- ification of laser beam		sound is a mechanical motion of molecules		microphones, telephones	
MECHANICAL (Movement)	rubbing hands, friction in general	non-electrical sparks	vocal cords, musical instruments			electric generator	cyclotrons & other high en- ergy machines
CHEMICAL	gas furnaces, fuels in general	fuel burning, fire-fly pho- sphorescence	firecrackers, other explosives			fuel cell battery	
ELECTRIC	incandescent light, iron, cooking	fluorescent light, television	telephone speakers, radio, etc.	motor	charging storage battery		
NUCLEAR	nuclear reactor, fus- ion reaction	nuclear bomb	nuclear bomb	nuclear bomb		"nuclear batteries"	

Evaluation Sheet

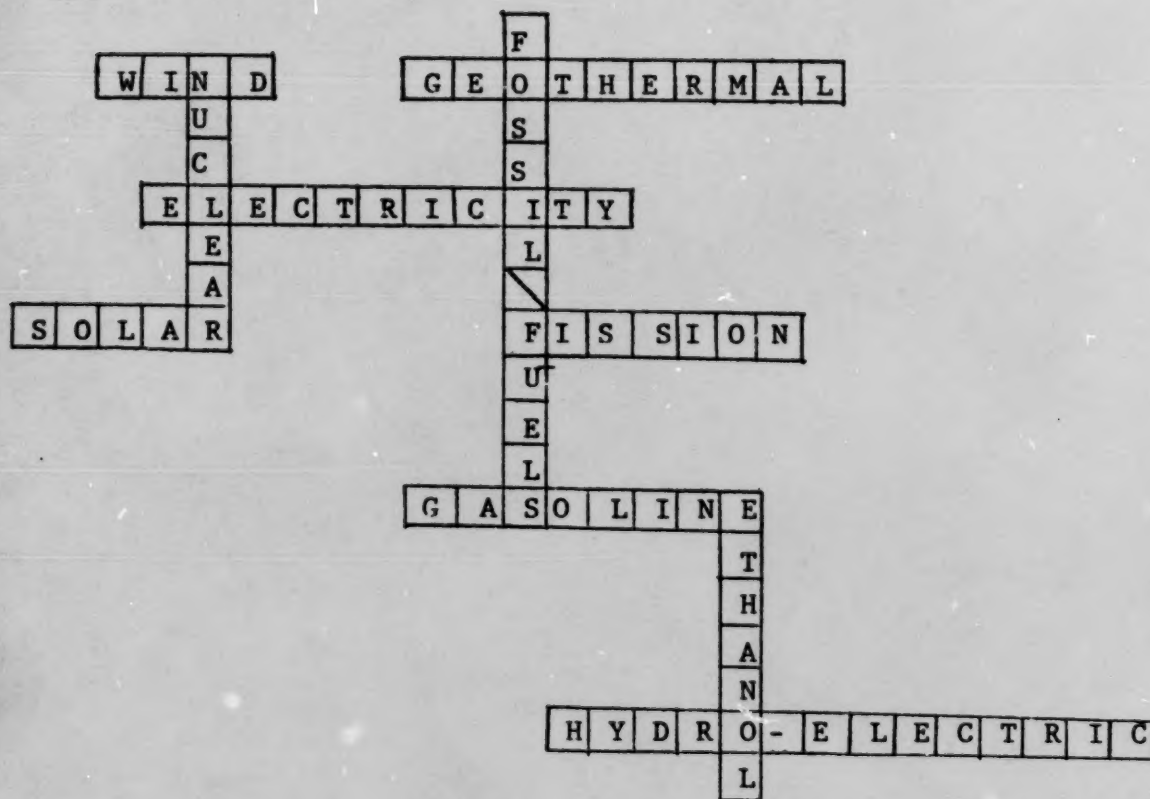
Directions: Write in each box examples of one form of energy being converted into another form. Begin with the vertical column on the left. Example: Heat is converted into light energy in a light bulb, so write "light bulb" in the box formed by the intersection of the two energy forms.

	HEAT	LIGHT	SOUND	MECHANICAL (Movement)	CHEMICAL	ELECTRIC	NUCLEAR
HEAT							
LIGHT							
SOUND							
MECHANICAL (Movement)							
CHEMICAL							
ELECTRIC							
NUCLEAR							



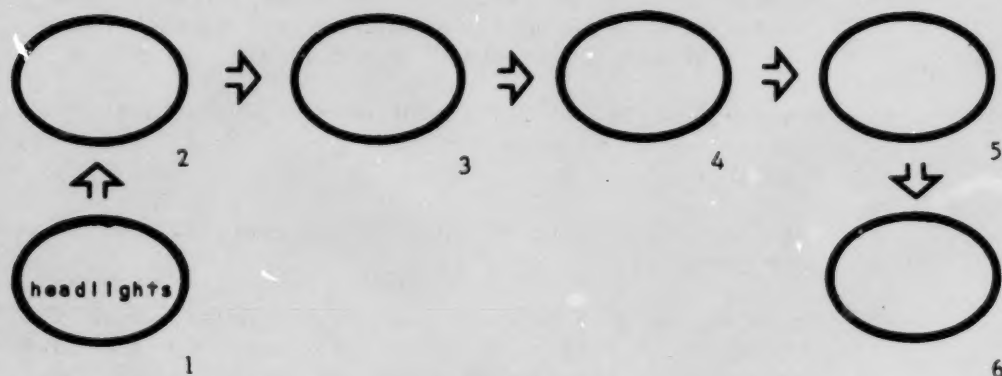
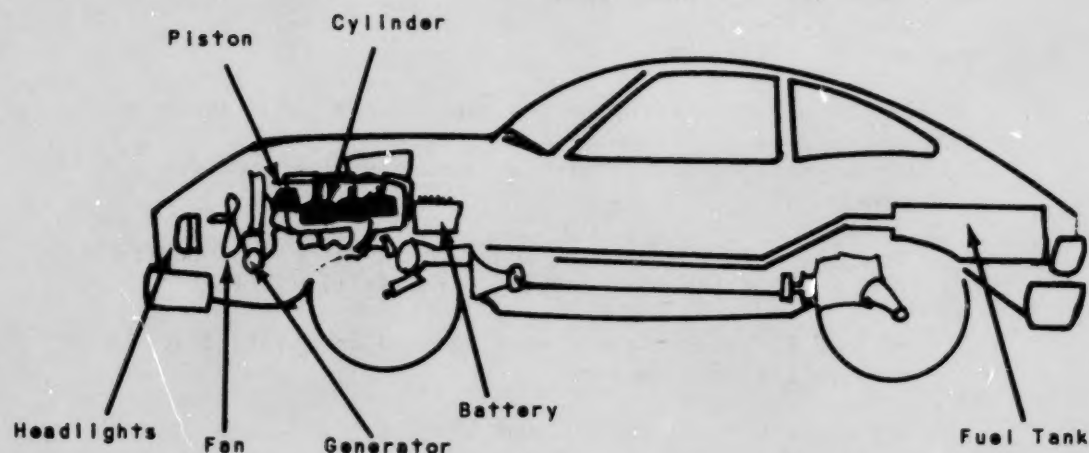
Hydro-Electric
Wind
Fossil
Geothermal
Nuclear
Fuel
Nuclear
Gasoline
Solar
Ethanol
Electricity

ANSWERS TO STUDENT ACTIVITY #3



Tracing Energy Conversion in an Automobile

Directions Take an automobile trip backwards by tracing the light energy in an automobile back to its original source. Fill in each numbered block with the name of the appropriate energy form: heat, light, chemical, etc., and with what part of the car makes this conversion possible. The first space has been filled in to help you.



AMERICA'S WOODEN AGE

How Can We Find the Energy Content in Wood?

Materials 1 small cardboard juice can with metal bottom
 1 large juice can
 1 ring stand with clamp
 100 ml water
 wire screen
 1 thermometer
 1 platform balance
 1 glass stirring rod
 wood shavings (different kinds)
 graduated cylinder
 matches

- Procedure (Note: To aid in setting up the apparatus - see diagram on the next page.)
1. Cut a piece of screen wire as shown in diagram (next page).
 2. Bend the legs of the wire down and the sides up - this will prevent the wood shavings from falling off.
 3. Weigh 2.75 grams of wood shavings and carefully place them on the wire basket.
 4. Set 2 match heads in the wood shavings (for easy lighting).
 5. Punch 2 holes in the sides of the small juice can near the top rim. Put the glass stirring rod through these holes. Attach a ring stand (see diagram).
 6. Measure out 100 milliliters of water. Put it into smaller can (1 ml of water = 1 g or .001 kg). Record on data sheet.
 7. Take the temperature of water before heating. Record on data sheet.
 8. Punch a couple of holes around the circumference of the bottom of the large can. Remove the bottom of the large can. Ignite the wood shavings and quickly place the larger can over the burning wood shavings.
 9. Lower the small can into the larger can using the ring clamp.
 10. Use your thermometer to measure the temperature of the water after heating. Record on the data sheet.

11. Record the change in the temperature of the water on the data sheet. Specific heat of water = $\frac{1 \text{ calorie}}{1 \text{ gram } 1^{\circ}\text{C}}$
12. Multiply the temperature change x the mass of the water x .001 to get the heat gained by water. Record on data sheet. (The .001 is for changing grams x Celsius to Calories.)

13. Find the heat content of wood.

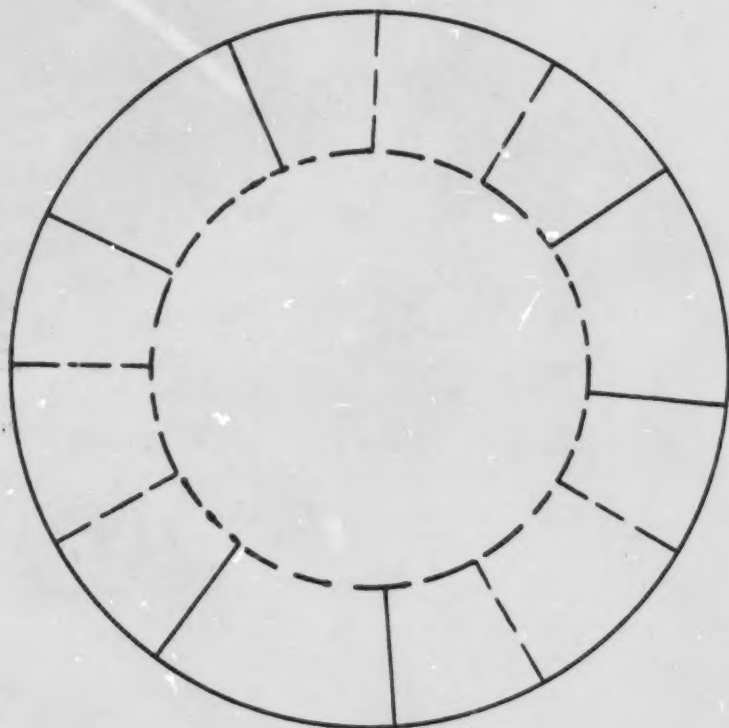
$$\frac{\text{heat output}}{\text{mass of wood}}$$

Record on data sheet.

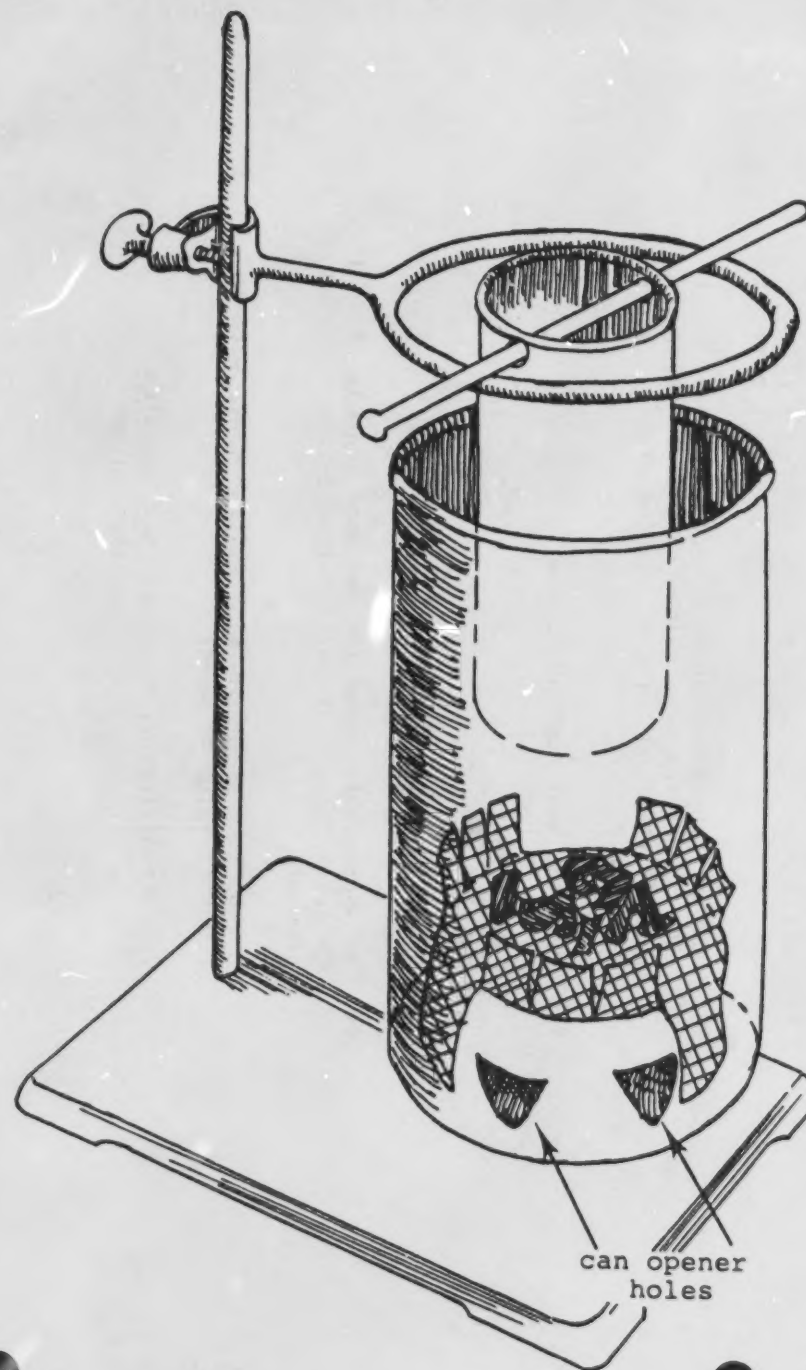
14. An approximate value for the heat content of wood is 1250 Calories/lb or 2.76 Cal/g. This is the accepted standard.
15. How do your experimental results compare with the accepted value of wood?

$$\text{Percent difference} = \frac{\text{experimental results}}{\text{accepted value}}$$

Screen Wire



Note: Cut along solid lines



SUGGESTED TEST

True or False (Circle correct answer)

- T F 1. The prime source of the majority of earth's energy is a star.
- T F 2. "Fossil fuels" refer to the remains of plants and animals buried under the earth.
- T F 3. Petroleum means "rock oil".
- T F 4. Hydroelectric power supplies one fourth of the energy of the U.S.
- T F 5. Water power from dams is the most dependable long range power source available.
- T F 6. Fuel cells and nuclear fusion are two of man's newest energy sources but are limited in use at present because of cost.
- T F 7. MHD stands for "magneto hydrogen diffusion".
- T F 8. Environmental problems are caused by concentrating or combining one or more of the elements.
- T F 9. Wind power is used to produce both mechanical and electrical energy.
- T F 10. The production and consumption of energy is directly related to the production and consumption of materials and food and also to population and pollution.

PRE-POST TEST

Energy Transitions in United States History

WOOD HYDROELECTRIC COAL OIL GEOTHERMAL NATURAL GAS

1. Which of the above was a primary source of energy during the following periods of U.S. History?
 - a. The Colonial Period? _____
 - b. The period from 1820 to 1900? _____
 - c. The period from 1900 to the present? _____
2. Which of the following is not a unit of energy measurement? _____
 - a. BTU
 - b. joule
 - c. watt
 - d. calorie
3. Name three commonly used items that require oil to manufacture.
 - a. _____
 - b. _____
 - c. _____
4. Who was Edwin Drake? _____
 - a. He invented the gasoline engine.
 - b. He drilled the first oil well.
 - c. He founded U.S. Steel.
 - d. He was the captain of the first steamship.
5. List two reasons why the demand for energy sharply increased from the period 1820 to 1920.
 - a. _____
 - b. _____
6. The amount held by an average freight car is: _____
 - a. equivalent to a gallon of gas
 - b. a stack measuring 4 x 4 x 8 ft.
 - c. the amount that can be carried on the back of a strong donkey
 - d. the amount burned in the average fireplace in a week of continuous use

7. What's wrong with this idea?
- "In order to conserve its precious supplies of fossil fuels, the U.S. should switch from coal and oil to electricity."
8. Reproduce Graph #2, Student Handout #3, Oil Lesson, "U.S. Oil Imports." The statement that can be drawn from this graph is that: _____
- a. The U.S. has stopped drilling for oil.
 - b. Americans are using less electricity.
 - c. Oil imports steadily increased from the period between 1960 and 1977.
 - d. Americans paid more for oil in 1977 than in 1960.
9. What does "OPEC" stand for? _____
- a. Organization of Petroleum Exporting Countries
 - b. Oil Producing Energy Cartel
 - c. Operational Plan for Energy Conservation
 - d. Organization for the Promotion of Environmental Controls
10. A "turbine" _____
- a. converts mechanical energy to chemical energy
 - b. converts heat energy to mechanical energy
 - c. converts mechanical energy to electrical energy
 - d. converts chemical energy to mechanical energy
11. Reproduce picture on page 100 without labels.
- A. This picture shows: _____
- a. The process of cooling hot water created when electricity is generated
 - b. The generation of electricity from fossil fuels
 - c. How a boiler works
 - d. The path that electricity takes through a power plant
- B. Using the following terms, label the parts of the system: fuel supply, cooling pond, furnace, boiler, turbine, condenser, generator.
- C. This system would most likely be found: _____
- a. in a factory
 - b. in a power plant
 - c. in a house
 - d. aboard a ship

12. Reproduce picture on page 98, "Producing an Electric Current." This picture demonstrates: _____
- how an electric current is generated
 - how a magnet works
 - how a galvanometer works
 - how a meter can be used as a compass
13. Which of the following statements best explains the relationship between the growth of railroads and the increase in the use of coal during the same period of U.S. history? _____
- Those developments are entirely coincidental.
 - Coal was used to fuel locomotives and to manufacture rails.
 - Railroads were used to transport coal.
 - Railroad lines were owned by the coal companies.
14. The term "energy intensive" is used to designate: _____
- Process and manufactured goods which require large amounts of energy.
 - A process that requires an energy source having a high "energy per pound" ratio.
 - A power plant that produces electricity for industrial purposes.
 - Energy sources which cost more than the goods and services produced by using them.
15. Which of the following statements best explains why coal replaced wood as a primary source of energy for the U.S.? _____
- Coal was less expensive than wood.
 - The U.S. was running out of wood.
 - Coal mining provided greater employment opportunities than wood cutting.
 - Coal was easier to transport and contained more energy per pound than wood.
16. A "generator": _____
- converts mechanical energy to electrical energy.
 - converts heat energy to mechanical energy.
 - converts electrical energy to chemical energy.
 - converts chemical energy to heat energy.
17. The formation of coal requires: _____
- hundreds of years.
 - thousands of years.
 - millions of years.
 - This depends upon the level of technology.

ANSWERS TO PRE-POST TEST

1. a. wood
b. coal
c. oil
2. c
3. (See page ____)
4. b
5. (Growth of population, development, increase in transportation, more demand for consumer goods.)
6. b
7. (Most electricity generated by burning fossil fuels.)
8. c
9. a
10. b
11. A. b
B. See picture
C. b
12. a
13. b
14. a
15. d
16. a
17. c

EQUIPMENT/SUPPLIES

Supplies:

1. The Modernized Metric System Chart
U.S. Department of Commerce
National Bureau of Standards
2. The Metric System of Measurement
3. Transparencies--U.S. Department of Commerce
4. Energy Pretest-Posttests
5. Crossword puzzles
6. Evaluation Sheet--Energy Conversion Charts
7. Energy Conversion in Automobile Sheets
8. Energy Content in Wood Activity Sheets
9. Quizzes

Equipment/Materials:

1. 1 small cardboard juice can with metal bottom
2. 1 large juice can
3. 1 ring stand with clamp
4. 100 ml. water
5. Wire screen
6. 1 thermostat
7. 1 platform balance scale
8. 1 glass stirring rod
9. wood shavings (several kinds)
10. graduated cylinder
11. matches

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

ENERGY AND POWER

Title of Unit:

FOSSIL ENERGY

DESCRIPTION OF UNIT

This unit describes fossil fuels and their importance to man's technological world. It will cover the basic fossil fuels man uses; the three most common forms of fossil fuels; the petrochemicals produced from oil; the products derived from coal and gas; the importance of fossil energy in transportation and transportation industries. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVES

After completion of this unit the student will be able to demonstrate an understanding of fossil fuels and where they come from. The student will be able to describe the source of fossil fuels and how they were formed. The student will be able to list products derived from fossil fuels. The student will develop an understanding and awareness of the role of fossil fuels in transportation.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. List job opportunities related to coal, oil and natural gas.
2. List products derived from coal, natural gas and oil.
3. Discuss orally or in writing, as directed, the role of fossil fuels as an energy source for transportation.
4. Explain how transportation is so very dependent upon fossil energy.

OUTLINE OF CONTENT

I. What are Fossil Fuels

Fuels which are the remains of plants and animals buried in the earth.

A. Coal--Solid fossil fuel.

1. Anthracite coal--hard coal
2. Bituminous coal--soft coal
3. Lignite coal--brown coal
4. Charcoal--manufactured coal
5. Coke--manufactured coal

B. Oil--Petroleum--"Rock oil"

1. Crude oil--Oil as it is pumped from the earth. (Black Gold)
2. Gasoline--Product used primarily as a motor fuel made from oil (about 1/2 crude oil).
3. Kerosene--Fuel used in many jet engines.
4. Jet fuel--Fuel very much like kerosene but with more heavy oil.
5. Diesel oil--Product of crude oil used in diesel engines for fuel.
6. Heating oil--Product of crude used primarily for home heating fuel.

C. Gas--(Natural Gas) Fossil fuel in gaseous state--often found in oil fields. It is usually a mixture of gases.

1. Methane--One form of natural gas, chief gas in natural gas.
2. Propane--Derived from natural gas.
3. Butane--Derived from natural gas.
4. Liquefied petroleum--LP fuel gas.
5. Manufactured gases--Gases made from coal, coke or petroleum.

II. Petrochemicals

Chemicals made from petroleum. There are over 2,000 products made from petroleum.

- A. Medical chemicals--Many medical products are made from oil, coal and gas.
- B. Paint--Pigment.
- C. Rubber--Pigment.
- D. Plastic--The most of today's plastic products comes from coal, oil or gas.
- E. Fertilizer--Natural gas is one essential ingredient in the production of fertilizer.

III. Transportation

The moving of people or products from one place to another.

- A. Air transportation--Aircraft and rockets used in flight.
- B. Land transportation--Trains, trucks and automobiles.
- C. Water transportation--Ships and barges used to carry goods.
- D. Jobs in transportation--Many thousands of jobs are directly or indirectly related to fossil fuels and transportation.

TEACHER ACTIVITIES

1. Prepare transparencies on job opportunities in petroleum industry. (p. 44-45 Geil & Johnson, Energy and Transportation: Industry and Careers).
2. Prepare transparency on products from oil (p. 43 Yadon, Energy and Transportation: Small Engines).
3. Prepare transparency on petrochemical family tree. (p. 20 Geil, Energy and Transportation: Power).
4. Prepare teacher-made test on fossil fuels.
5. Prepare terminology sheet for students.

STUDENT ACTIVITIES

1. Study transparency material as presented.
2. Fully describe, orally or in writing as directed, one job relating to fossil fuel industries, that the student is personally interested in.
3. Study terminology sheet.
4. Match terms to appropriate definitions.
5. Take test.

REFERENCES/RESOURCES

References:

1. Cook, Earl, Man, Energy, Society, San Francisco, CA: W.H. Freeman and Co., 1976.
2. Geil, John J. and Johnson, Stephen, Energy and Transportation: Industry and Careers, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
3. Geil, John J., Energy and Transportation: Power, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
4. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

Resources:

1. Transparency masters
2. Information sheets

STUDENT ACTIVITIES

1. Study transparency material as presented.
2. Fully describe, orally or in writing as directed, one job relating to fossil fuel industries, that the student is personally interested in.
3. Study terminology sheet.
4. Match terms to appropriate definitions.
5. Take test.

REFERENCES/RESOURCES

References:

1. Cook, Earl, Man, Energy, Society, San Francisco, CA: W.H. Freeman and Co., 1976.
2. Geil, John J. and Johnson, Stephen, Energy and Transportation: Industry and Careers, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
3. Geil, John J., Energy and Transportation: Power, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
4. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

Resources:

1. Transparency masters
2. Information sheets

Terms and Definitions

1. Fossil fuel--Fuel produced by animal and vegetable matter buried in the earth.
2. Coal--Solid fossil fuel.
3. Coke--Manufactured fuel made by heating bituminous coal.
4. Charcoal--Manufactured fuel made from wood.
5. Anthracite coal--Hard coal.
6. Bituminous coal--Soft coal (most useful coal).
7. Lignite coal--Brown coal. Possesses high water content.
8. Crude oil--Oil or petroleum as it is pumped from the ground.
9. Gasoline--Motor fuel used primarily for automobiles and piston engine aircraft.
10. Diesel fuel--Primary fuel for diesel engines made from crude oil.
11. Methane--Primary gas in natural gas.
12. Petrochemicals--Any of the more than 2,000 chemicals derived from coal, oil and gas.

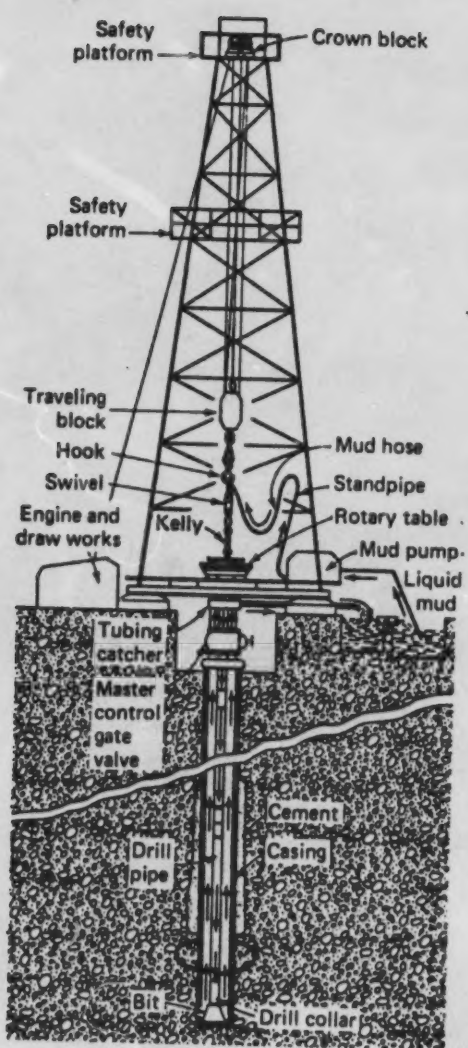
FOSSIL ENERGY AND TRANSPORTATION

I. Oil

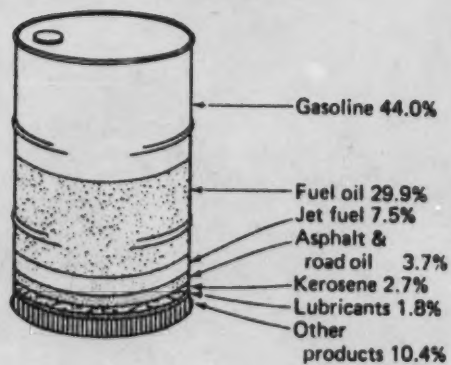
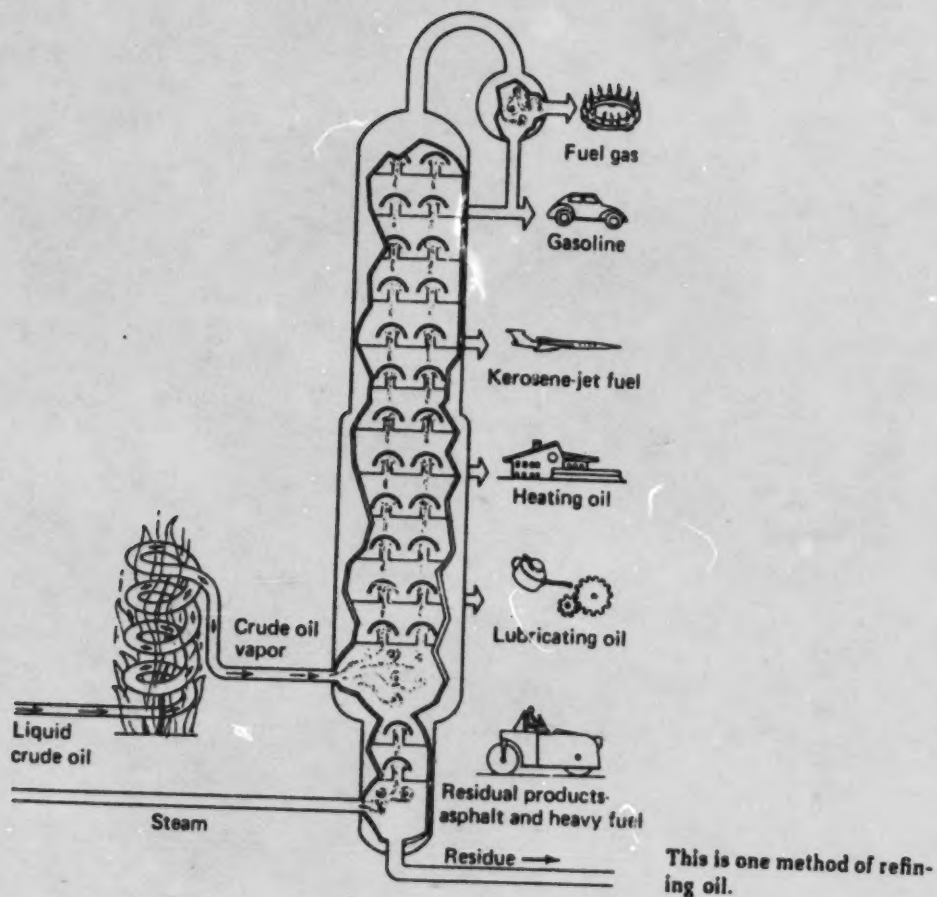
- A. Gasoline--Transportation of people in automobiles uses millions of barrels of gasoline each day.
- B. Diesel fuel--Most trucks, trains, and many ships use diesel fuel for transporting goods.
- C. Jet fuel is used by most airlines to transport people.
- D. Other products from oil, such as asphalt, are used to make highway paving for transporting goods and people.
- E. Heating oil and other products are used in homes and factories.

II. Coal

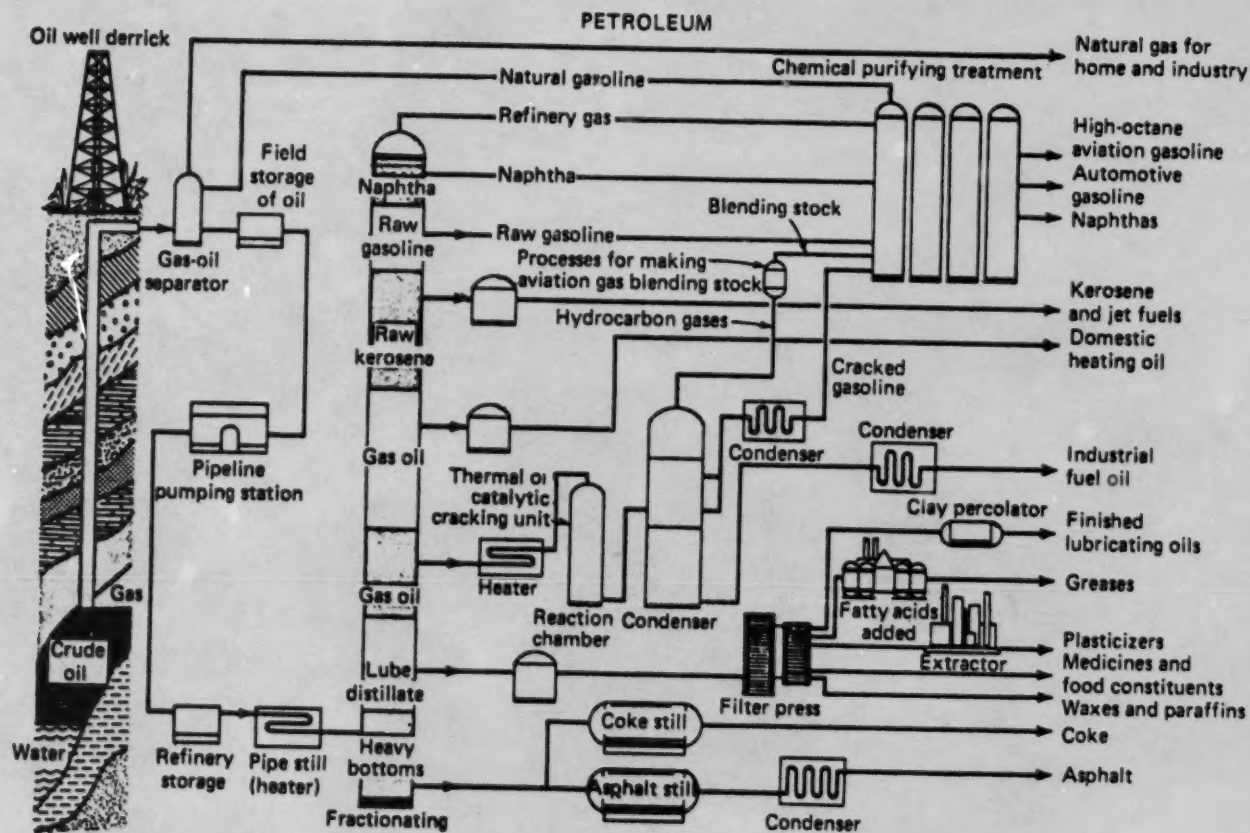
- A. Coke--Coke is used in the processing of iron ore into steel. All vehicles use iron and steel, especially cars and trucks. The engines and frames are made of steel.
- B. Oil--Coal oil is used in steam engines and ship engines.
- C. Light oil--May be used for lubricating oil in engines.
- D. Coal gas is used primarily for heating.



Rotary oil and gas drilling rig.



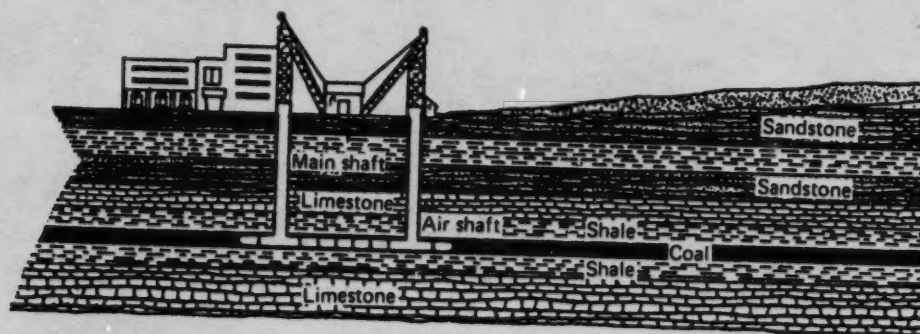
The products made from oil are used in many ways.



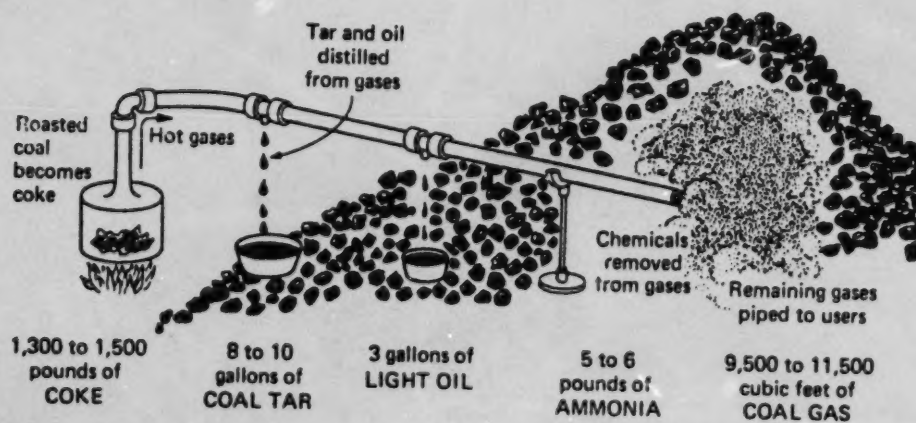
Petroleum processing. This is what happens in a refinery.



The United States has huge deposits of coal. (National Coal Assoc.)



A sectional view showing how a shaft mine operates. (National Coal Assoc.)



Products from a ton of coal.

JOB TITLES	AREAS OF OPPORTUNITY					
	Exploration and production	Transportation, supply, distribution	Refining	Marketing	Research and development	Staff departments
Accountant						
Analysts						
Distribution		◊ □				
Financial						
Operations		◊ □		◊ ○	● ●	● ●
Planning		◊ □		◊ □	● ●	● ●
Programs		◊ □			● ●	● ●
Systems		◊ □				● ●
Traffic		◊ □				● ●
Chemist	○		○	○	● ●	● ●
Computer Scientist					● ●	● ●
Economist			◊			● ●
Engineers						
Chemical	□	□	□		□	
Civil	□			□		
Development		□			□	
Drilling	□					
Electrical	□	□	□		□	
Industrial	□		□			□
Mechanical	□	□	□	□	□	
Petroleum	□		□	□	□	
Process	□		□		□	
Production	□				□	
Research					□	
Reservoir	□				□	
Safety						
Systems	□	□	□	□	□	□
Geologist	○	○			○	○
Geophysicist	○				○	○
Land Person	◊				○	○
Mktg. Research Spec.				●		●
Mathematician					○	
Metallurgist	□				○	
Oceanographer		○				
Paleontologist		○			○	
Personnel Spec.					○	
Petrographer	○				○	○
Physicist	○				○	
Programmer				◊ □		
Purchasing Agt.				◊ □		
Sales Rep.				◊ □		
Statistician						○

◊ Business Degrees

□ Engineering Degrees

○ Liberal Arts & Science Degrees

● Advanced Degrees Desirable

JOB TITLES	AREAS OF OPPORTUNITY						JOB TITLES	AREAS OF OPPORTUNITY					
	Exploration and production	Transportation, supply, distribution	Refining	Marketing	Research and development	Staff departments		Exploration and production	Transportation, supply, distribution	Refining	Marketing	Research and development	Staff departments
Aircraft Personnel							Automotive						
Dispatcher							Electronic						
Mechanic							Equipment						
Pilot							Officer (Marine)						
Boilermaker							Oil Blender						
Bookkeeper							Oiler						
Brickmason							Operators						
Captain (Marine)							Boilerhouse						
Cargo Blender							Bulldozer						
Carpenter							Compressor						
Clerks							Crane						
Accounting							Generator						
Freight							Metering Sta.						
Mail							Pump						
Cook							Radio						
Derrick Person							Seismograph						
Designer (Equip.)							Tabulating Mach.						
Drafts People							Painter						
Civil							Pipefitter						
Electrical							Pipeline Crew Person						
Geological							Repair Person						
Mechanical							Instrument						
Driller							Tool						
Electrician							Rig Builder						
Engineers							Rigger						
Marine							Roustabout						
Radio							Sea Person						
Refrigeration							Secretary						
Expediter							Service Sta. Optr.						
Fire Fighter							Service Sta. Sales Rep.						
Fuel Oil Dealer							Sheetmetal Worker						
Gager							Shooter						
Independent Jobber							Still Person						
Inspectors							Surveyor						
Equipment							Technicians						
Pipeline							Laboratory						
Seismograph							Radio						
Instrument Maker							Tester						
Log Plotter							Tool Dresser						
Machinist							Truck Driver						
Maintenance Person							Typist						
Mechanics							Welder						

Most jobs in the petroleum industry require a high school diploma and special training or experience.

EQUIPMENT/SUPPLIES

Equipment:

1. Tight fitting containers to display liquid and solid samples.

Supplies:

1. A sample of gasoline
2. A sample of kerosene
3. A sample of diesel fuel
4. A sample of heating oil
5. Transparencies
6. Tests
7. Samples of pigments made from fossil fuels
8. Samples of plastics made from fossil fuels
9. Samples of fertilizers made from fossil fuels
10. Samples of coal and coke

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

ENERGY AND POWER

Title of Unit:

SOLAR ENERGY

DESCRIPTION OF UNIT

This unit will cover Solar Energy. An overview of the place of Solar Energy or Sun Energy in the total concept of energy is important and will include the following areas: the nature of Solar Energy; how much solar energy the earth receives; how solar energy is the source of most of the earth's energy supply; some of the methods of using solar energy; some methods of direct solar energy use; some methods of indirect solar energy use; how active solar conversion works; how passive solar energy works; the future of solar energy; you and solar energy jobs. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to: identify terms and definitions related to solar energy; list direct uses of solar energy; list indirect sources of solar energy; define and explain active and passive solar conversion devices; describe energy use and perform solar experiments to show the use and effect of solar energy.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. The student will orally or in writing as required identify 10 terms relating to solar energy.
2. List and describe:
 - A. Three indirect solar energy conversion products.
 - B. Two direct solar energy conversion devices.
 - C. Two possible solar energy conversion devices.
 - D. Two future jobs or occupational fields relating to solar energy use.
3. Perform one or more solar energy experiments as directed to demonstrate the use of solar energy.

OUTLINE OF CONTENT

I. What is Solar Energy

Solar energy is the energy from the sun or sun energy. The energy comes from the sun to the earth by radiation. This radiation is both visible and invisible.

A. The sun. A star. The center of our solar system.

1. The sun's energy--Most of the sun's energy comes from the atomic process of fusion--or the joining of two hydrogen atoms to form one helium atom and energy.
2. The sun's size--The sun is approximately 864,000 miles in diameter or about 88 times as large as the earth.
3. The sun's distance--The sun is 93,000,000 miles from earth.
4. The sun's mass--The sun has a mass of 1.98×10^{33} grams.

(NOTE: See Bell System Science Experiment No. 2 for more complete information on the sun's mass conversion.)

B. Earth's solar energy--The quantity of solar energy received by the earth.

1. Solar radiation intensity--The quantity of solar radiation at 93,000,000 miles from the sun: 0.135 watts per square centimeter.
2. Total solar energy--The earth receives more than 25 times as much solar energy than we get from coal, oil, and gas.

C. Using solar energy. How solar energy is used on earth.

1. Natural use--Almost all of earth's energy comes from the sun and most is used by some natural method.
2. Photosynthesis--The process of plants using sunlight to produce food for growth.
3. Heat--Most of the earth's heat comes from the sun.
4. Wind--The change in temperature of the earth surface causes the air to move causing wind.

II. Man-made Solar Devices

Devices which use solar energy to create usable energy.

- A. Greenhouses--Houses which are covered with glass or clear plastic (any substance which will allow light to pass through it).
- B. Solar panel--A panel which is designed to trap solar energy for use.
- C. Solar collector--A device which collects solar energy for use.
- D. Solar cell--A device which converts solar energy into electricity.
- E. Solar furnace--A device which focuses or concentrates solar energy to increase the temperature in a small area.
- F. Fresnel lens--A thin transparent plate which focuses light at a given point.
- G. Lens--Glass or clear material used to focus light.

III. Solar Applications for Transportation

- A. Very limited use of solar energy in transportation.
- B. Indirect use such as wind for sailing devices.

TEACHER ACTIVITIES

1. Provide student with unit outline and information sheet concerning relevant terminology.
2. Provide transparencies illustrating solar energy concepts.
3. Gather necessary materials and prepare instruction sheets for solar energy experiments. (See Science Activities in Energy--Solar II.)
4. Prepare teacher-made test covering unit.

STUDENT ACTIVITIES

1. Read and study information sheets.
2. Study application of terms and concepts to illustrations given on transparencies.
3. Perform solar energy experiments as instructed.
4. Take Test.

REFERENCES/RESOURCES

References:

1. Chapin, D.M., Energy from the Sun, Bell Telephone Labs, Baltimore, MD: Waverly Press, 1965. (Out of Print)
2. Oak Ridge Associated Universities, Science Activities in Energy-Solar II, The American Museum of Science & Energy, Oak Ridge, TN: Oak Ridge Asso. University.*
3. Walker, John R., Exploring Power Technology, South Holland, Ill: Goodheart-Wilcox Company, 1976.

Resources:

1. Definition Sheets
2. Activity Sheets (Experiments 1 and 5 from Science Activities in Energy-Solar II)

*Free materials

Terms and Definitions

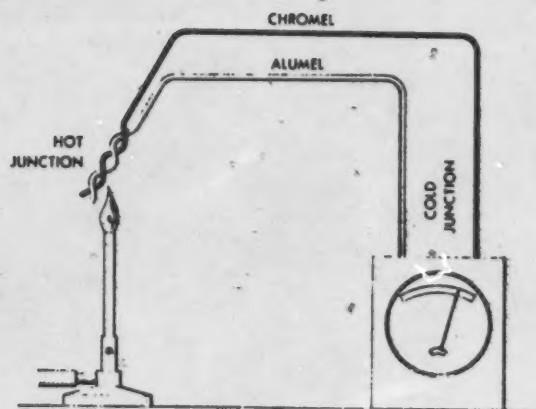
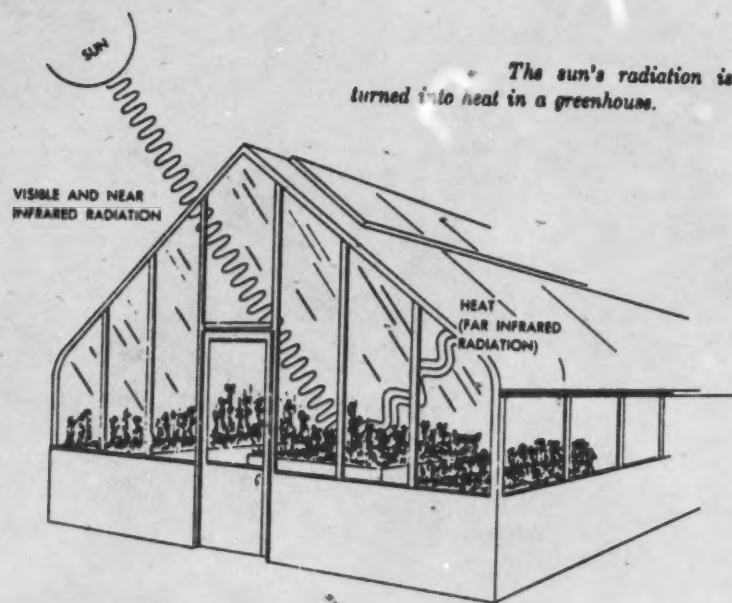
1. Sun--A star. The center of our solar system from which we receive almost all of our energy.
2. Fusion--The thermonuclear (heat-atomic) process of combining hydrogen atoms into helium atoms with energy given off as a by-product. The only place that this occurs naturally is in the sun.
3. Silicon-Glass--a special type of glass crystal produced to make solar cells.
4. Fresnel--A lens using concentric (common center) circles on a flat plate to focus light.
5. Crucible--Container used to heat materials to high temperature.
6. Photosynthesis--The process plants use to produce food from carbon dioxide and chemicals by the use of sunlight.
7. Greenhouse--A device which uses sunlight to produce heat inside, usually to grow plants.

SOLAR APPLICATION

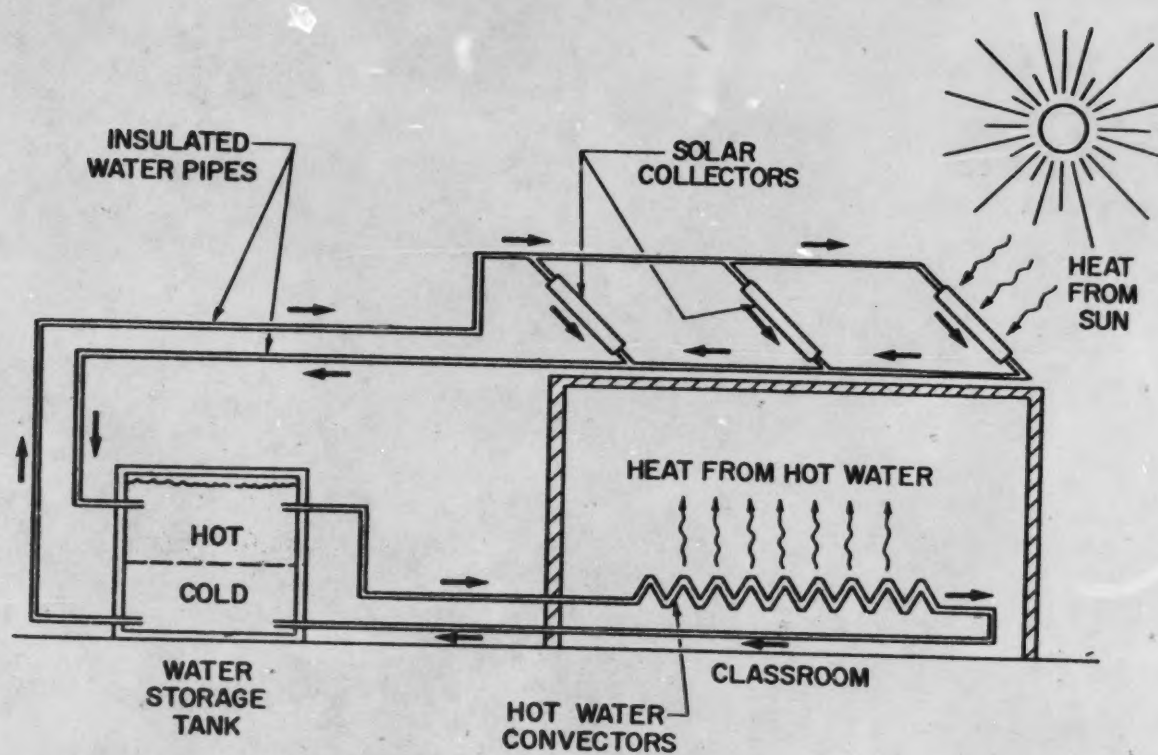
Solar energy is not used directly for transportation.

Experimental vehicles have been developed to use solar energy for transportation. These units include electric powered vehicles using solar cells and solar energy to produce power to move the vehicle. The success is limited because of the size of the solar cell area. Solar sails which use solar "winds" or streams of protons have been tested in space. These sails work but are quite limited.

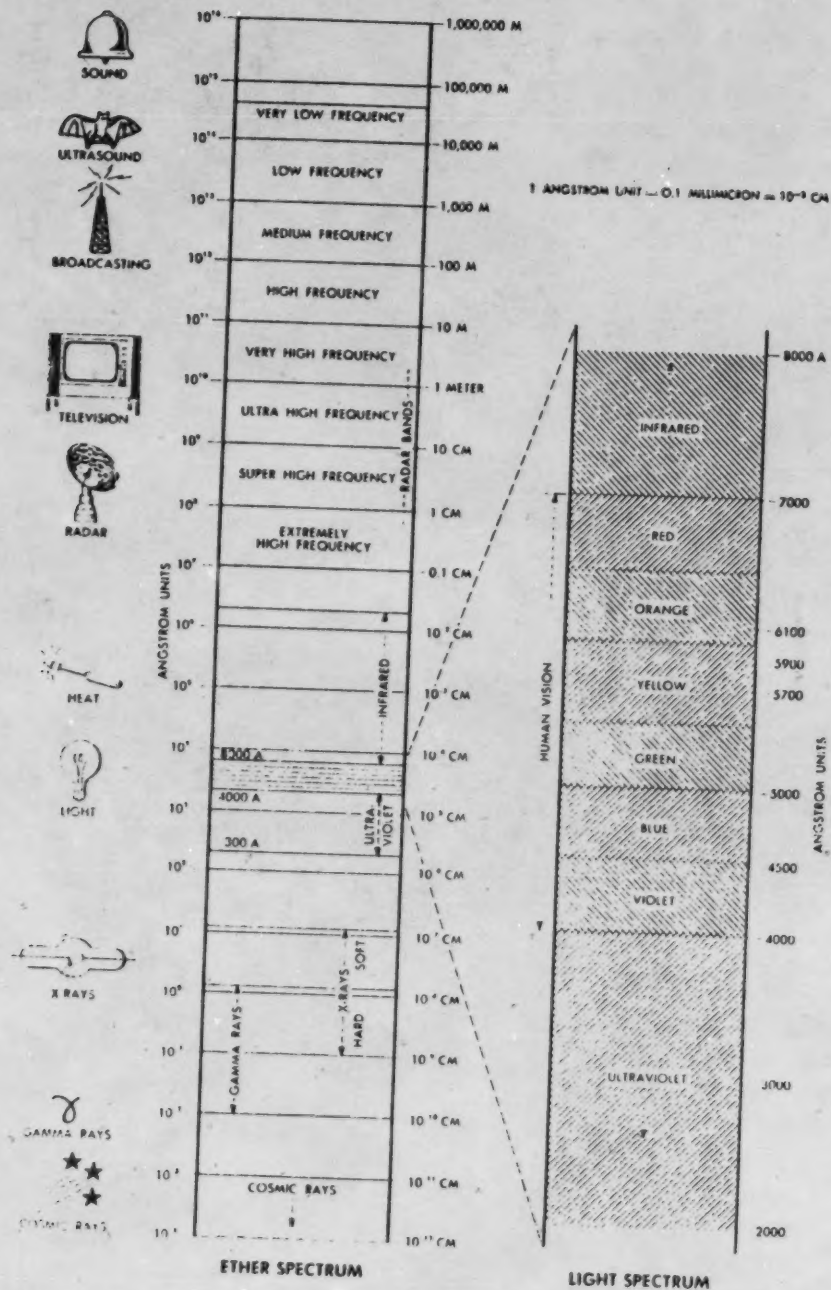
The most promising use of solar energy in transportation is for the production of electricity and its use to provide electricity in remote pumps or pumping stations.



Thermocouple effect.



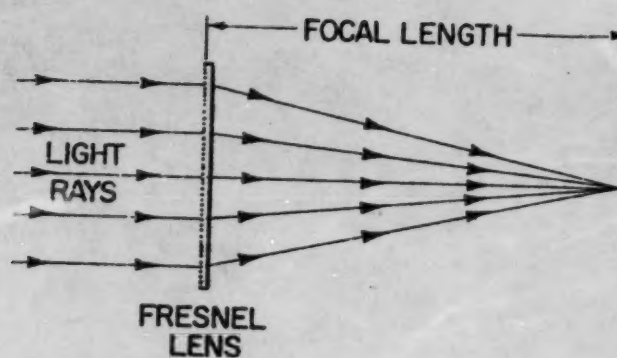
Schematic showing how solar energy is employed to heat school. (AAI Corp.)



ETHER SPECTRUM

LIGHT SPECTRUM

Electromagnetic spectrum. (Based on information from ELECTRONICS, a McGraw-Hill publication.)



How FOCAL LENGTH is determined.

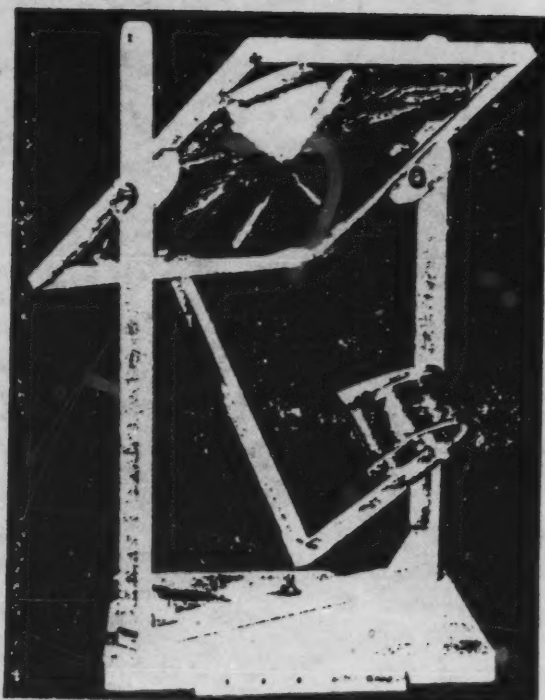
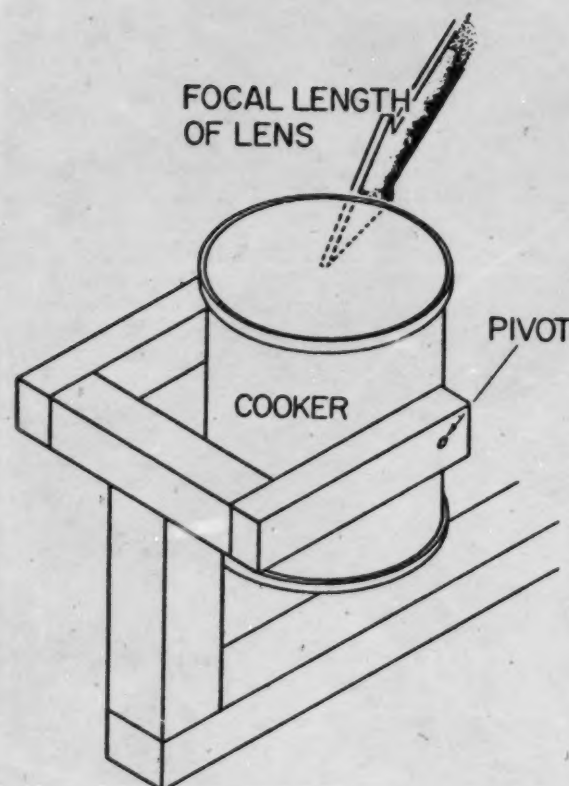
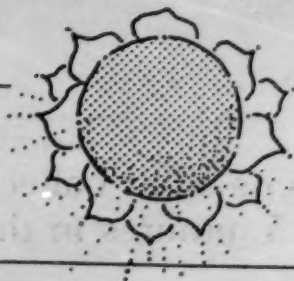


Fig. 20-19. A shop-made solar furnace utilizing a Fresnel lens to concentrate the sun's rays.



Addition necessary to convert solar furnace shown in Fig. 20-19 into a camp cooker. Do not forget to open the canned goods before placing them in the cooker.

How much solar heat comes from the sun to you?



Materials

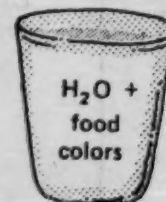
2 Foam cups
2 Thermometers
Food colors; aluminum foil
Graduated cylinder
Metric ruler; watch
Insulation material (packing foam, crumpled newspaper, etc.)
Cardboard box (should be same height as cups; trim if necessary.)

Set Up Your Experiment

Fill the foam cups with a measured amount of cold water.
Add food colors to one cup.



COVER THIS CUP WITH ALUMINUM FOIL TO REFLECT SUNLIGHT.



ADD FOOD COLORS TO H₂O IN THIS CUP TO MAKE THE WATER AS BLACK AS POSSIBLE—THIS ABSORBS SUNLIGHT.

Trim a cardboard box to the same height as the cups.

Put the cups in the box and add the insulation material.

Put the box in the sun for 10 minutes. (Noon to 1 p.m. is usually hottest.)

Stir the water in the cups with the thermometers and record the temperatures.



TOP OF BOX EVEN WITH TOP OF CUPS



PACK INSULATION INTO ALL SPACES AROUND THE CUPS

Do This Calculation:

$$\text{Area} = \frac{\pi d^2}{4} = \text{square centimeters}$$

$$\text{Calories} = \frac{\text{ml of H}_2\text{O in 1 cup} \times \text{Difference in temperatures of both cups after being in the sun for 10 minutes.}}{\text{Area (square centimeters) of water} \times 10}$$

Note:

Scientists have measured the amount of solar energy beyond our atmosphere at about 2.0 calories per square centimeter per minute. About 1.5 calories per square centimeter per minute reaches earth after passing through our atmosphere. This is called the Solar Constant.

The "calories" calculation is the amount of solar heat received on 1 square centimeter in 1 minute at your location.

Multiply x 10,000 to get the results for 1 square meter!

Other Ideas to Explore

What percentage of the total amount of solar energy is available at your location?

Would you have enough energy to heat your house if the south side of your roof was covered with solar collectors?

Can you think of a more accurate way to do this experiment?

Where do you think most of the errors exist in this experiment?

Science Activities in Energy

Which batch-type solar collector gets the hottest after 15 minutes in the sun?



Materials

Plastic trash bags;
one each white, green,
and black
(local grocery store)

Insulating material
(styrofoam, cardboard,
newspaper, etc.)

Aluminum foil

3 thermometers

Tape

Prepare the Collectors

Make 3 plastic trash bag solar collectors by following the drawing below. On the ground outside, put down insulating material, and then aluminum foil. The bags go on top in a row.



Record the temperatures of the 3 collectors, and place the collectors on the foil in the sun.

Record the temperatures again in 15 minutes.

What causes the differences in temperatures recorded?

How could this affect other solar experiments?

	TEMP. BEFORE	TEMP. AFTER
GREEN		
WHITE		
BLACK		

Other Ideas to Explore

Try this experiment with 2 bags of the same color. Prepare these solar collectors in the same way and place them in full sun, one on insulation material and foil and the other directly on the ground.

Record the temperatures as above and compare the results.

EQUIPMENT/SUPPLIES

Supplies necessary for one student:

1. Two foam cups
2. Three thermometers
3. Food colors
4. Aluminum foil
5. Graduated cylinder
6. Metric ruler
7. Watch
8. Insulation material (packing foam, crumpled newspaper, etc.)
9. Cardboard box (same height as foam cups)
10. Plastic trash bags; one each of white, green, and black
11. Tape

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

ENERGY AND POWER

Title of Unit:

POWER (MECHANICAL ENERGY)

DESCRIPTION OF UNIT

This unit will cover the fundamental concepts of power. It will provide an overview of several areas of power; how energy and power are related; the conversion of energy into power; how power is measured; how power is transmitted; the mechanics of power; the mathematical formula used to describe; work, power, force, torque, pressure and horsepower. The unit will include simple machines and how to use simple machines to gain mechanical advantage. The materials in this unit are designed for 5 hours of instruction.

UNIT OBJECTIVES

After completion of this unit the student will be able to identify terms and give definitions. The student will be able to explain several areas of power and how energy and power are related. The student will be able to apply his knowledge of power to solve problems. The student will be able to demonstrate uses of simple machines and devices to produce work, force, torque, pressure and mechanical advantage.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Match specific terms and definitions.
2. List sources of power.
3. List 3 methods for transmitting mechanical power.
4. Define the 3 methods of input motion of mechanical power.
5. Explain, orally or in writing, the term inertia.

EP 4.2

6. Explain, orally or in writing, the term momentum.
7. State the formula for work and solve one simple problem.
8. State the formula for horsepower (HP) and solve one simple problem.
9. State the formula for torque and solve one simple problem.
10. State the formula for pressure and solve one simple problem.
11. State the formula for force and work one simple problem.
12. Demonstrate and explain 3 classes of levers.

OUTLINE OF CONTENT

I. Power

Energy per unit time or work per unit time. The rate of energy per second is used to define the quantity of work done in a given time. The standard English unit of power is the Horsepower (33,000 foot pounds per minute or 550 foot pounds per second). The metric standard is the erg.

II. Horsepower

The standard unit of measure in the English system. 33,000 ft/pound/min. or 550 ft. lbs./sec. The standard was derived by multiplying the actual work done by a horse in one minute by one and one-half. The amount is somewhat more than normal for a horse to do.

III. Inertia

The tendency of an object to remain in a state of rest or motion until acted upon by an outside force. An automobile will sit still on a level road until the force of the engine is applied to start it moving. This applied force overcomes static inertia. The auto tends to move even though it is shifted into neutral. This is moving inertia, the tendency of the object to continue in motion. The brakes are applied to stop the auto. This is the outside force (friction of brakes) which overcomes the moving inertia and stops the auto.

IV. Momentum

Momentum is the measured force produced by a moving object. An auto moving at 40 mph has twice the momentum that it would have at 20 mph.

V. Acceleration

Acceleration is an increase in the speed (mph-fps) of an object. To measure acceleration, the rate of increase in speed for a period of time is added to the initial speed. (Usually feet per second per second.) Example--Gravitational acceleration is 16 ft/sec/sec. That is an object will fall 16 ft. in one second from a point of inertia (still point). The second second, the object will fall 16 ft. + 16 more ft. (32 ft. total) because of its acceleration.

VI. Deceleration

The opposite of acceleration. Example--When a ball is thrown straight up into the air the force against the ball as it leaves the person's hand provides the acceleration. The force of gravity provides the deceleration; that is, it slows and finally stops the rise of the ball. Then the force of gravity will accelerate the ball back to the starting point (note the ball will have the same speed at any given point on its way down as it had on its way up).

VII. Force

The term given to the exertion or application of energy to an object or material. The force may be in the form of a push, pull, twice or other types of motion. Force is usually measured in pounds (lbs.) or kilograms (kgs.).

VIII. Friction

The resistance between two surfaces in contact. Sometimes we need friction such as a tire of an automobile in contact with the road surface. Sometimes we need to eliminate or reduce friction as in the use of oil on the surface of the cylinder and piston in an engine to help separate the surfaces and prevent friction. Note: friction always produces heat energy. See student activity.

IX. Work

Work = weight x distance. Work may be defined as useful motion--or motion which results in something useful being done. Work is the measurement of mechanical energy. Example--such as walking up a flight of stairs or lifting a weight from the floor to a table help to explain work. Work is measured in foot/pounds in the English system. Work is measured in Newton/Meters in the metric system.

Example: You lift a 100 pound box 2 feet up to the top of a table. How much work is done?

Work = weight x distance
 Work = 100 (lbs) x 2 (ft)
 Work = 200 ft. lbs. of work

X. Torque

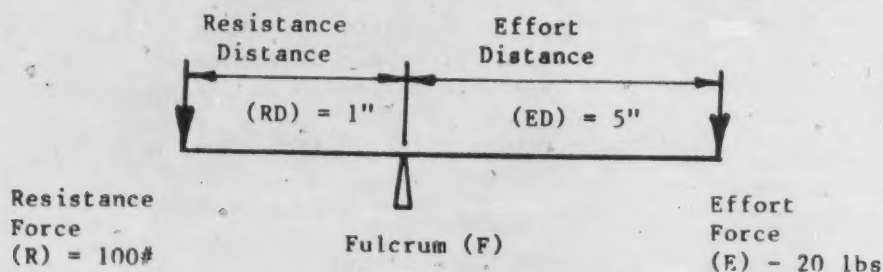
Torque is the measurement of force but does not require movement.

XI. Pressure

Pressure is a measurement of force over an area. The pressure is measured in pounds per square inch (PSI) in the English system. Pressure is measured in grams per square centimeter or kilograms per square meter in the metric system.

XII. Mechanical Advantage (MA)

The term used to express the relation of input force to output force. The advantage one gains by applying a small force through a greater distance to get a large force for a short distance. An example is one of the simple machines such as a class one lever. The illustration below shows the Mechanical Advantage or MA.



The weight (100#) can be lifted up by the force (20#) for each inch the weight moves the force must move 5 inches.

The Mechanical Advantage is 5 to 1. The formula below is used to express this ratio:

$$MA = \frac{\text{input dist.}}{\text{output dist.}}$$

$$\begin{aligned} \text{Input work} & \qquad \text{Output work} \\ \text{Force} \times \text{distance} &= \text{force} \times \text{distance} \\ 100 \times 1 &= 20 \times 5 \\ 100 \text{ inch/pounds} &= 100 \text{ inch pounds} \end{aligned}$$

XIII. Simple Machines

There are six simple machines or basic machines. All other machines are derived from these six simple machines. Machines which use two or more simple machines together are called compound machines. The six simple machines are the lever, inclined plane, wheel and axle, pulley, wedge and screw. These six are sometimes further condensed to the lever, the wheel and axle, and inclined plane. The pulley and the wheel and axle are quite closely related as is the inclined plane, the wedge and the screw.

XIV. Fluid Power

The transmission of power by the use of liquids or gases. The most common liquids are oil and water. The most common gas is air. The fluid is placed under pressure usually by some form of mechanical pump. The fluid transmits the force to some mechanical device which is acted upon and performs work or movement.

XV. Efficiency

The ratio of energy put into a system and the energy taken out of the system. This is expressed as:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100. \text{ The 100 provides for a percent.}$$

No machine or device is ever 100% efficient. There is always energy loss because of friction. Therefore the formula will always provide a figure less than 100%. Example:

$$\text{Efficiency} = \frac{\text{output}}{\text{input} + \text{losses (friction, heat, etc.)}} \times 100$$

TEACHER ACTIVITIES

1. Provide the student with the student module.
2. Make the required transparencies for power.
3. Explain the unit on power and give a brief overview.
4. Discuss the performance objectives and state which objectives the students will be required to complete.
5. Provide sample problems on chalkboard or overhead projector.
6. Give explanation of student activity sheets.
7. Give demonstrations 1, 2, & 3 as shown at the end of this unit.
8. Have students complete outside activity sheets as homework assignment.
9. Have students demonstrate in class the activities completed as homework.
10. Give quiz on power.

STUDENT ACTIVITIES

1. Study unit objectives.
2. Read information sheets.
3. Complete class activities as directed.
4. Do activities as assigned for homework.
5. Demonstrate activities in class.
6. Take Test.

REFERENCES/RESOURCES

References:

1. Bohn, Ralph C. and MacDonald, Angus, Power: Mechanics of Energy Control, Bloomington, Ill.: McKnight and McKnight Pub. Co., 1970.
2. Drake, George R., The Repair and Maintenance of Small Engines, Reston, Va.: Reston Publishing Co., 1976.
3. Geil, John J. and Johnson, Stephen, Energy and Transportation: Industry and Careers, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1976.
4. Roth, Alfred C., Small Gas Engines, South Holland, Ill.: Goodheart-Wilcox Co., 1975.
5. Stephenson, George E., Power Technology, Albany, N.Y.: Delmar Publishers, 1973.
6. Walker, John R., Exploring Power Technology, South Holland, Ill.: Goodheart-Willcox Co., 1976.
7. Worthington, Robert M., Margules, Morton and Crouse, William, General Power Mechanics, New York: McGraw-Hill Book Co., 1968.
8. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, N.J.: Prentice Hall, Inc., 1976.

Resources:

1. Information Sheets
2. Transparency Masters
3. Activity Sheets
4. Demonstration Sheets

Terms and Definitions

1. Power--Energy per unit time or work per unit time.
2. Horsepower--The standard unit of measurement in the English system. 33,000 ft/pounds/minute or 550 ft/pounds/sec.
3. Inertia--The tendency of an object to remain in a state of rest or motion until acted upon by an outside force.
4. Momentum--The measured force produced by a moving object. The force depends upon two things--mass and speed.
5. Acceleration--The increase in speed of an object measured in feet per second per second or meters per second per second.
6. Deceleration--The opposite of acceleration or the slowing down of an object.
7. Force--The term given to the exertion or application of energy to an object or material.
8. Friction--The resistance to movement of two surfaces in contact. Friction always produces heat energy.
9. Work--Useful motion or motion which results in something useful being done. Work is measured in terms of weight or force times distance ($W = F \times D$).
10. Torque--Torque is the measurement of force applied but does not require movement.
11. Pressure--The measurement of a force over an area usually expressed as pounds per square inch (PSI) or grams per square centimeter (GSC).
12. Mechanical advantage--Commonly called MA.
13. Fluid power--The transmission of energy by a fluid (liquid or gas). A term often applied to hydraulic systems.

POWER APPLICATION IN TRANSPORTATION

I. Power and Transportation

Power is the energy per unit time. In transportation power is required to move an object or material. Power is generally measured in Horsepower. Example: A 100 HP engine move an automobile.

II. Sources of Power for Transportation

Power is derived by the use of energy over a period of time. The source of energy may be a fuel (chemical) such as gasoline, diesel or coal. Nuclear power is also used to power some ships.

III. Horsepower in Transportation

A standard measure of power is foot-pounds--Watts or Joules. Transportation requires many horsepower. The smallest motorcycle may have one or more horsepower. Ships use many thousands of horsepower.

IV. Momentum and Transportation

Momentum is the force which results in the moving of any material. The greater the material the greater the momentum. Example: A train has a great force or momentum.

V. Acceleration and Transportation

The increase in speed of an object requires power or Horsepower. Jet aircraft must accelerate quickly to become airborne.

VI. Efficiency in Transportation

Economical transportation requires efficiency. How much energy is required to move an automobile one mile is a measure of efficiency.

VII. Inertia Result of Transportation

The transportation of materials such as oil, iron or canned goods involves inertia. Energy is required to overcome inertia. An engine works harder to start.

VIII. Force Used in Transportation

An engine, pump or motor is used to apply force to an object or a material to move the material.

IX. Work in Transportation

Work is weight $\times$ distance. Transporting any material or object (a car, truck, train, plane or ship) requires work.

X. Torque and Transportation

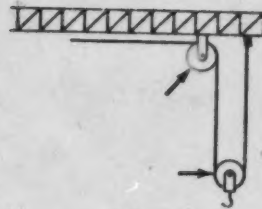
Torque is developed when a force is applied in a circular motion. (Rotating engine, turbine pump motor or propeller). This torque results from the tendency of the engine or motor to spin in an opposite direction from the rotation of the engine or motor output shaft.



Lever



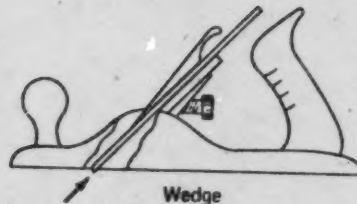
Wheel and axle



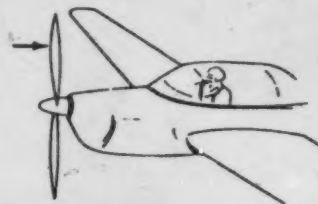
Pulley



Inclined plane

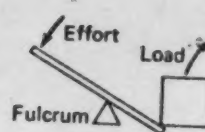


Wedge

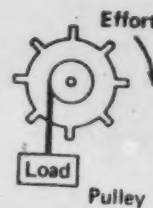


Screw

The lever, wheel and axle, pulley, inclined plane, wedge, and screw are found in various forms in all modern machines.



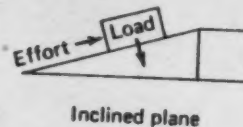
Lever



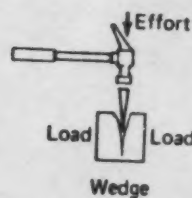
Pulley



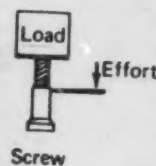
Wheel and axle



Inclined plane



Wedge



Screw



DIAGRAM OF CLASS 1 LEVER

First Class Levers.

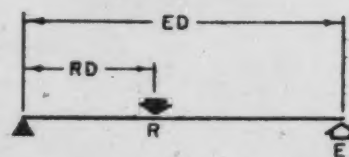
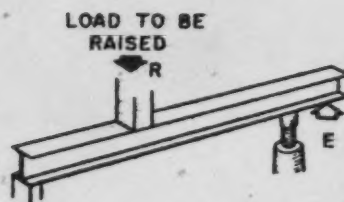


DIAGRAM OF CLASS-2 LEVER

Second Class Levers.

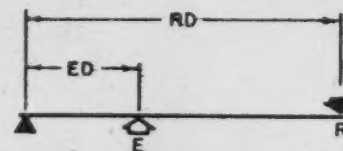
LOSS IN M.A.
AT E

DIAGRAM OF CLASS 3 LEVER

Third Class Levers.

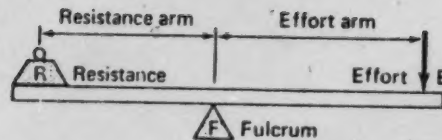
Levers fall into three categories — first class levers, second class levers, and third class levers.

First class levers place the fulcrum between the resistance and the effort force. These levers multiply force with a sacrifice in the distance the object is moved. The direction of movement is reversed.

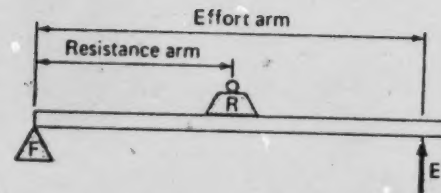
Second class levers place the fulcrum at the end of the lever with the resisting weight at a point along the lever. These levers also multiply force with a sacrifice in the distance the

object is moved. The direction of object movement is the same as that of the applied force.

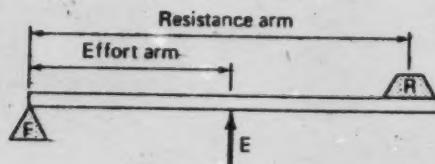
Third class levers place the fulcrum at the end of the lever with the resisting weight at the opposite end of the lever. The applied force or effort is at a point along the lever. These levers increase effort but multiply distance moved by the object and therefore have a negative mechanical advantage. A fishing rod illustrates this principle and sometimes the fisherman is mystified at how a small fish can create such a large pull on his rod. The fish has the mechanical advantage.



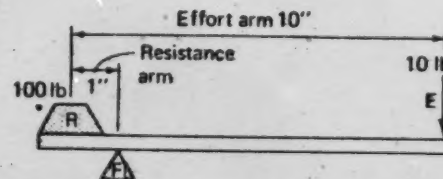
A Class 1 lever has the fulcrum placed between the effort and the resistance.



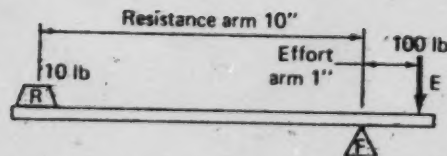
A Class 2 lever has the resistance placed between the effort and the fulcrum.



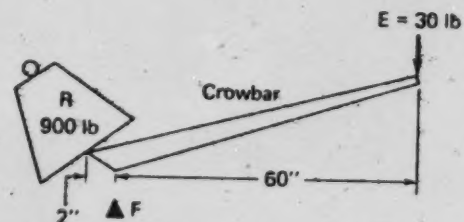
A Class 3 lever has the effort placed between the fulcrum and the resistance.



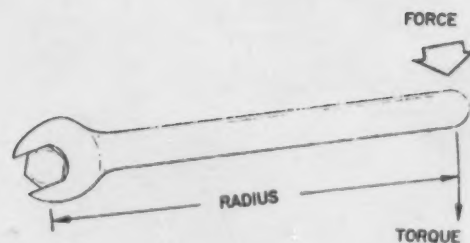
A Class 1 lever working as a force-multiplier with a mechanical advantage of 10.



A Class 1 lever working as a distance multiplier with a mechanical advantage of 0.1.



A crowbar is a Class 1 lever working as a force multiplier. Here 30 pounds lifts 900 pounds. The mechanical advantage is 30.



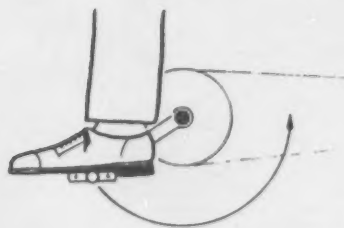
Torque Is a Force Applied to a Radius

what is the torque if a force
of 40 pounds is applied to a wrench 2 feet
long?

$$\text{Torque} = \text{Force} \times \text{Radius}$$

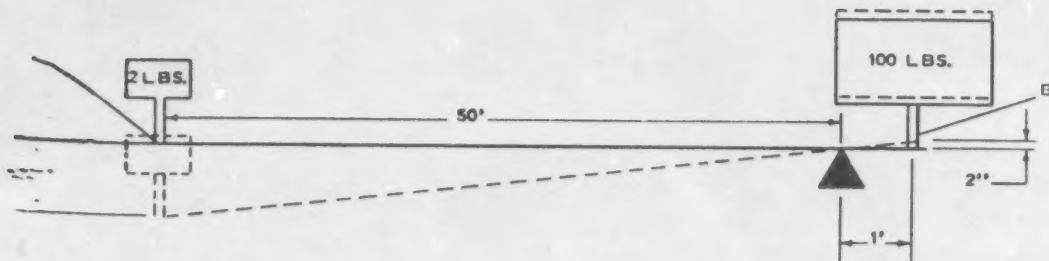
$$\text{Torque} = 40 \text{ lbs.} \times 2 \text{ ft.}$$

$$\text{Torque} = 80 \text{ pound-feet}$$

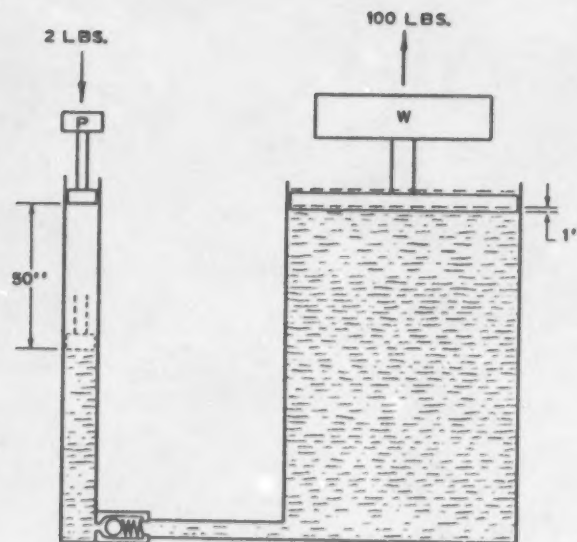


Torque Is Used to Pedal a Bicycle
and Turn a Bolt

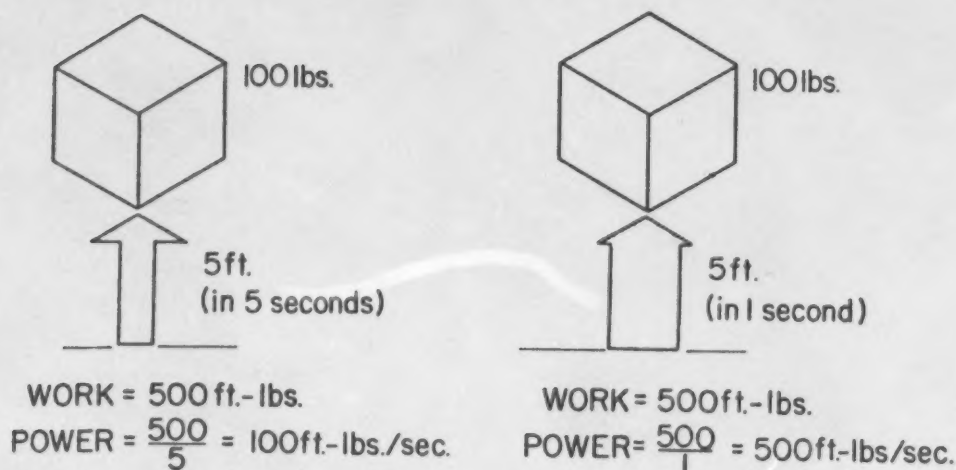
FLUID TRANSMISSION OF POWER



The Mechanical Advantage of a Lever Also Applies to Hydraulics.



Mechanical Advantage
in Hydraulics.



Power is the rate of doing work or the rate at which energy is used.

To find horsepower, use the equation:

$$\text{HORSEPOWER} = \frac{\text{Work}}{\text{Time (in minutes)} \times 33,000} \quad \text{or}$$

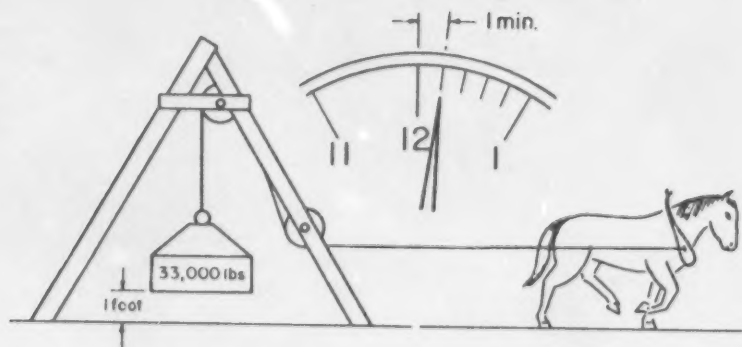
$$\text{HORSEPOWER} = \frac{\text{Work}}{\text{Time (in seconds)} \times 550}$$

For example, what will be the horsepower required to lift the 100 lb. 5 ft. off the ground if it were done in 5 seconds?

DO WORK and is measured in the same way as work — FOOT-POUNDS.

There are two types of energy.

POTENTIAL ENERGY is stored energy — the tightly wound watch spring; gasoline in an auto's tank; a cartridge in a loaded pistol.



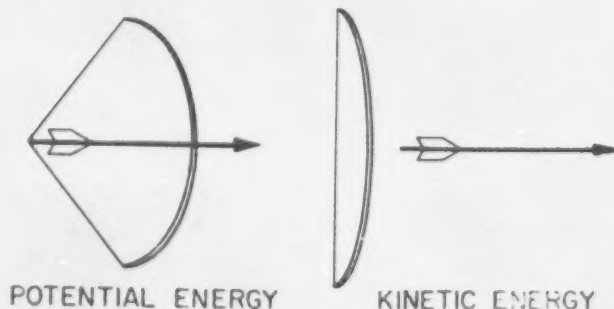
One horsepower is the ability to lift 33,000 pounds one foot in one minute.

$$\begin{aligned} \text{HORSEPOWER} &= \frac{\text{Work}}{\text{Time (in seconds)} \times 550} \\ &= \frac{5 \text{ ft.} \times 100 \text{ lb.}}{5 \text{ sec.} \times 550} \\ &= \frac{500}{2750} \\ &= .18^+ \text{ Horsepower} \end{aligned}$$

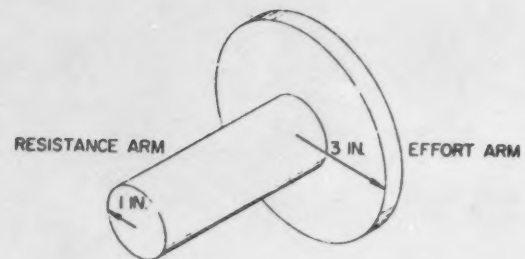
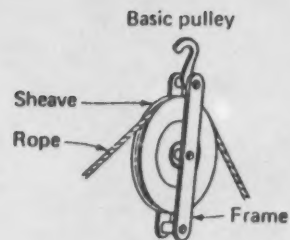
Will more horsepower or less horsepower be required to lift the same weight 5 ft. off the ground in 15 seconds?

ENERGY

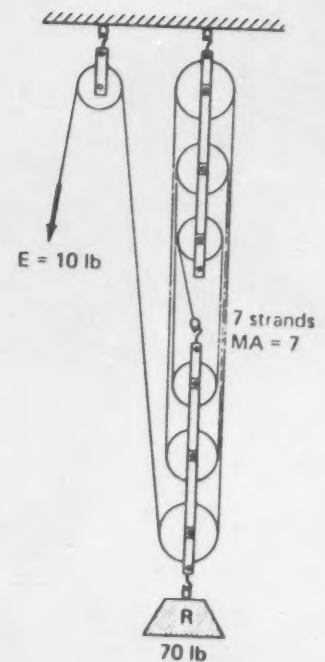
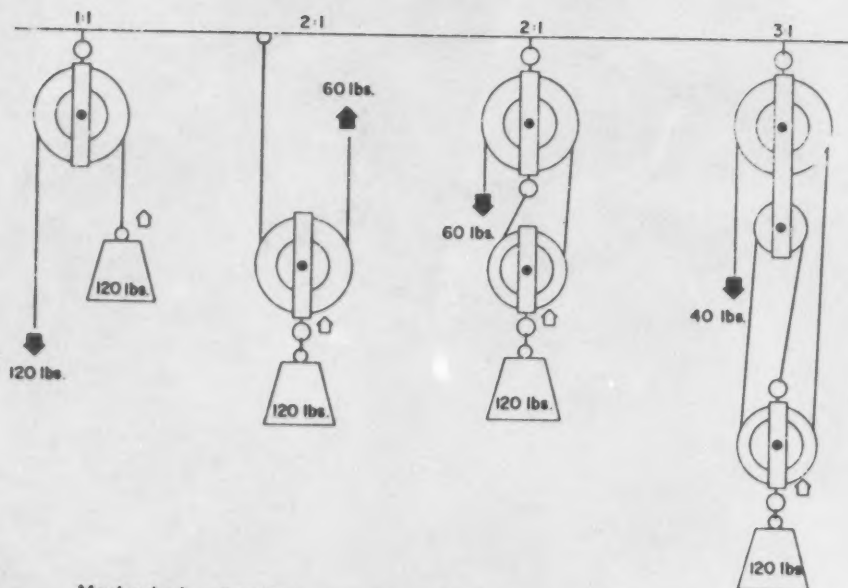
ENERGY is the term used to describe *THE ABILITY TO*



Two types of energy.

U.S.
Customary1 in.
3 in.SI
Metric25 mm
76 mm

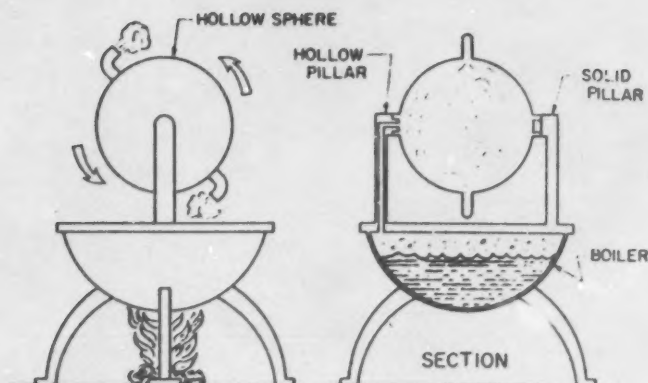
The mechanical advantage of the wheel and axle is the ratio between the two lever arms, which is 3 to 1.



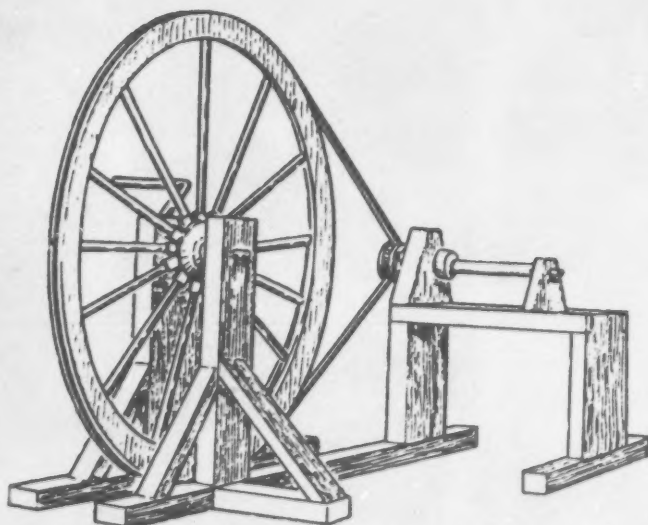
Mechanical advantage can be gained through the use of pulleys.

U.S.
Customary40 lbs.
60 lbs.
120 lbs.SI
Metric178 N
267 N
534 N

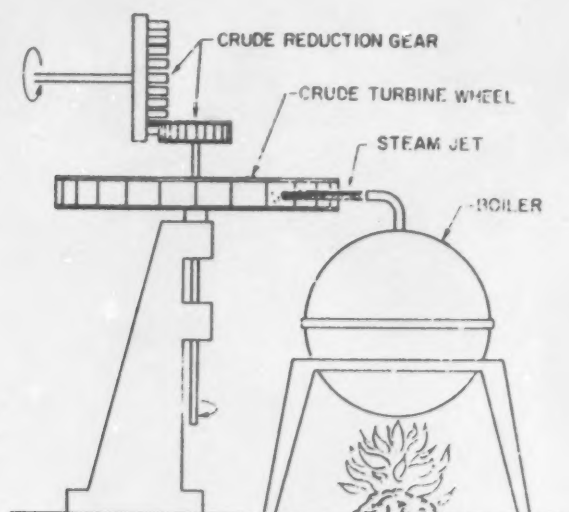
Early Power Sources



Hero's Whirling Aeolipile (pronounced ee OH lih pill) was the father of all modern heat engines and was the first jet propulsion engine made by man. Hero named it after Aeolus the god of winds in Greek mythology. The engine was never employed to operate machinery.



The great wheel lathe permitted skilled workers to keep all of their attention on the work. Turning the wheel provided work for persons who were blind or who had been crippled.



In 1629 Giovanni Branca, an Italian engineer, invented the first practical turbine. Like the Aeolipile, it was never more than a curiosity.

Demonstration #1

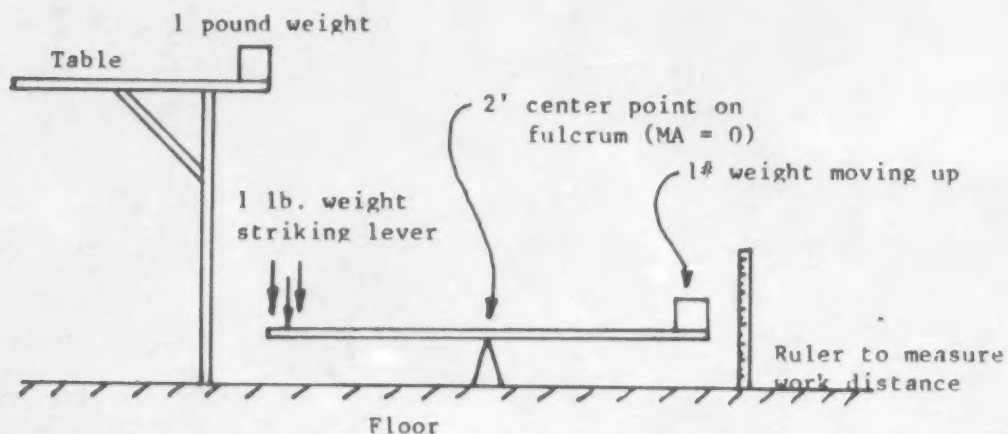
Demonstration of Potential Energy and Kinetic Energy

Equipment:

1. 5# weight (2 ea)
2. 1# weight (2 ea)
3. 2# weight (2 ea)
4. Ruler or yardstick
5. Fulcrums, 1 ea., 1" x 1" x 1" and 2" x 2" x 2"
6. 4' 3/4" x 3 3/4" board
7. 1 spring type fish scale
8. Screw eyes
9. String

Procedure:

Position the weights and lever as shown below. Using the 5# weight on the lever and the 1# weight on the table, push the weight off the table. (Note: The weight is the potential energy source). The falling weight is the kinetic energy source. When the weight strikes the lever the kinetic energy becomes the force (weight x distance) to act upon the lever (Mechanical ratio = 0 2' F x D = 2' R x D). The weight resting on the lever is moved upward. This is considered work on weight x distance. Does the weight move up to the same height as the table? Why not? (See Demonstration #2) Repeat the experiment using different weights on the table and different weights on the lever.



Demonstration of Work

Using the materials and setup in Demonstration #1 do the following experiments mine work.

Use equal weights (1 lb. - 2 lb. & 5 lb.) one on the table the other on the lever. Drop each weight from the table to the lever and measure the height the weight on the lever is raised. Using the formula for work, determine how many ft. lbs. of work are accomplished.

Answer the questions below:

1. Does the weight on the lever rise to the height of the table?

Why or why not? _____.

2. Where does the energy go? _____

3. What would improve this energy change? _____

Efficiency. Using the same materials and data in Experiment #1 determine the efficiency of the machine. (It is a machine just as a spring board is a machine).

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100$$

$$E = \frac{\text{height of weight (moved up by lever)} \times \text{weight in lbs.}}{\text{height of weight on table} \times \text{weight in lbs.}} \times 100$$

$$E = ?$$

Demonstration #3

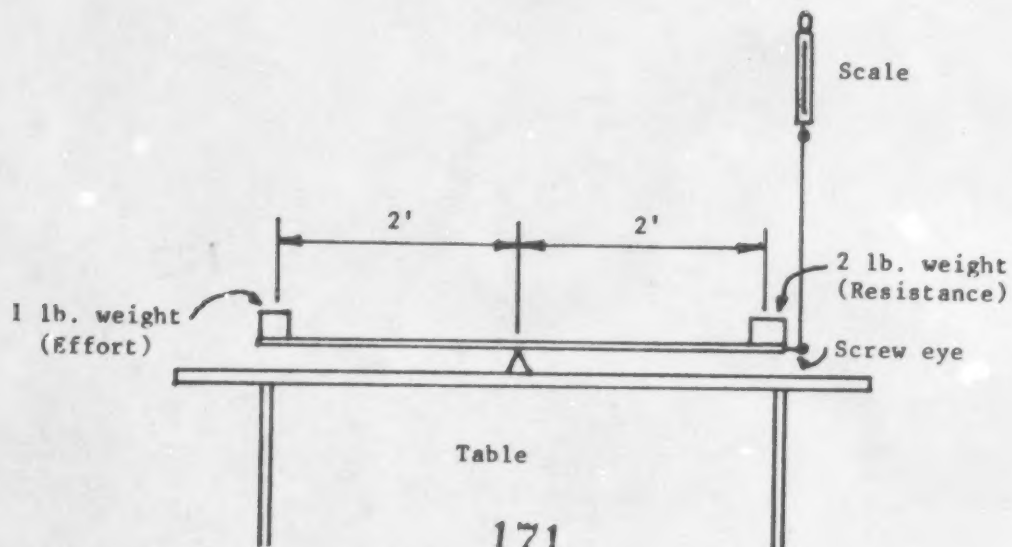
Classes of Levers

Using the setup shown for Demonstration #3 perform the following demonstrations and solve the problems for 3 classes of levers.

1. Place the lever directly centered on the fulcrum. Place one 2# weight on one end of the lever. (This is the resistance force or $F = W \times D$ or $F = 2' \times 2 \text{ lb.}$ $F = 4 \text{ ft. lbs.}$)
2. Place one 1 pound weight on the other end of the lever. (This is the effort force or $F \times W \times D$; $F = 2' \times 1 \text{ lb.}$; $F = 2 \text{ ft. lbs.}$)
3. Attach a string and spring type fish scale to the end with the one pound weight.

Now answer these questions:

- A. Does the lever balance? _____
 - B. What class of lever is this? _____
 - C. How much effort must be added by pulling up on the string with the fish scale attached? _____
 - D. Why does the fish scale require more than 1#? _____
 - E. What is the efficiency? _____
4. Using several different weights work out the various classes of levers by moving the weights and fulcrum to various points and distance.



ANSWERS TO DEMONSTRATIONS #2 and #3

Demonstration #2:

1. No Losses due to friction.
2. Changes into heat
3. Harder wood, stiffen lever. Anything which would keep energy from being absorbed.

Demonstration #3:

3. A. No
- B. Class 1
- C. 1 x lbs.
- D. Loss caused by friction
- E. Approximately 90%

Student Activity #1

Demonstration of Potential Energy and Kenetic Energy

Equipment:

1. 5# weight (2 ea)
2. 1# weight (2 ea)
3. 2# weight (2 ea)
4. Ruler or yardstick
5. Fulerums 1 ea. 1" x 1" x 1" and 2" x 2" x 2"
6. 4' 3/4" x 3 3/4" board
7. 1 spring type fish scale
8. Screw eyes
9. String

Procedure:

Position the weights and lever as shown below. Using the 5# weight on the lever and the 1# weight on the table, push the weight off the table. (Note: The weight is the potential energy source). The falling weight is the kenetic energy source. When the weight strikes the lever the kenetic energy becomes the force (weight x distance) to act upon the lever (Mechanical ratio = $0.2' F \times D = 2' R \times D$). The weight resting on the lever is moved upward. This is considered work on weight x distance. Does the weight move up to the same height as the table? Why not? (See Demonstration #2) Repeat the experiment using different weights on the table and different weights on the lever.

Demonstration of Work

Using the materials and setup in Demonstration #1 do the following experiments and determine work.

Use equal weights (1 lb. - 2 lb. & 5 lb.) one on the table the other on the lever. Drop each weight from the table to the lever and measure the height the weight on the lever is raised. Using the formula for work determine how many ft. lbs. of work are accomplished.

Answer the questions below:

1. Does the weight on the lever rise to the height of the table?
_____ Why or why not? _____.
2. Where does the energy go? _____
3. What would improve this energy change? _____

Efficiency. Using the same materials and data in Experiment #1 determine the efficiency of the machine. (It is a machine just as a spring board is a machine).

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100$$

$$E = \frac{\text{height of weight (moved up by lever)} \times \text{weight in lbs.}}{\text{height of weight on table} \times \text{weight in lbs.}} \times 100$$

$$E = ?$$

Student Activity #3

Classes of Levers

Using the setup shown for Demonstration #3 perform the following demonstrations and solve the problems for 3 classes of levers.

1. Place the lever directly centered on the fulcrum. Place one 2 lbs. ; eight on one end of the lever. (This is the resistance force or $F = W \times D$ or $F 2' \times 2 \text{ lb.}$ $F = 4 \text{ ft. lbs.}$)
2. Place one 1 pound weight on the other end of the lever. (This is the effort force or $F \times W \times D$; $F = 2' \times 1 \text{ lb.}$; $F = 2 \text{ ft. lbs.}$)
3. Attach a string and spring type fish scale to the end with the one pound weight.

Now answer these questions:

- A. Does the lever balance? _____
 - B. What class of the lever is this? _____
 - C. How much effort must be added by pulling up on the string with the fish scale attached? _____
 - D. Why does the fish scale require more than 1 lb.? _____
 - E. What is the efficiency? _____
4. Using several different weights work out the various classes of levers by moving the weights and fulcrum to various points and distance.

SUGGESTED TEST

List the following:

1. Three types of potential energy you see around your home.
 - a.
 - b.
 - c.
2. Three classes of levers and tell one place each is used.
 - a.
 - b.
 - c.
3. Six simple machines and give a common use of each one you see in use daily.
 - a.
 - b.
 - c.
 - d.
 - e.
 - f.
4. Three ways machines, especially engines, are inefficient. Tell how to demonstrate each.
 - a.
 - b.
 - c.

ANSWERS TO SUGGESTED TEST

1.
 - a. fuel (gasoline)
 - b. battery (flashlight)
 - c. water tank - spring
2.
 - a.
 - b.
 - c.
3.
 - a. wheel and axle (bike)
 - b. lever
 - c. wedge
 - d. inclined plane
 - e. pulley
 - f. screw
4.
 - a. heat (exhaust)
 - b. heat (friction)
 - c. fumes (incomplete combustion)

EQUIPMENT/SUPPLIES

Equipment:

1. Wrench, torque wrench
2. Pliers
3. Tongs--fire or welding
4. Dividers
5. Plane
6. Hammer
7. Pulleys
8. Wedge
9. Screws and bolts
10. 5# weights (2 ea)
11. 2# weights (2 ea)
12. 1# weights (2 ea)
13. Yardstick
14. Spring type fish scale

Supplies:

1. Transparencies
2. Activity Sheets
3. Screw eyes
4. String
5. Boards
6. 1" x 1" x 1" block
7. 2" x 2" x 2" block

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

ENERGY AND POWER

Title of Unit:

CHEMICAL ENERGY

DESCRIPTION OF UNIT

This unit will explain the concept of chemical energy, some sources of chemical energy, methods of using chemical energy, devices which convert chemical energy into usable energy forms and possible future uses of chemical energy devices for transportation. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to describe chemical energy in relation to chemical fuels. The student will be able to list several chemicals and several devices which use chemical energy.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. List 3 direct chemical converters.
2. Orally or in writing describe the operation of a fuel cell.
3. Construct a simple wet cell. (Storage battery wet cell)
4. Orally or in writing explain the difference between a standard zinc-carbon cell and an alkaline cell.

OUTLINE OF CONTENT

I. What is Chemical Energy

Chemical energy is energy directly from chemicals into a usable energy form.

- A. Chemical energy--Chemical energy is the form of a solid, liquid or gaseous form.
- B. Chemical fuel--Fuel which is potential source of energy.
- C. Electrolyte--One form of chemical energy. Used in the direct conversion of chemicals into electricity.

II. Direct Chemical Converters

Devices which convert chemical energy directly into electrical or thermal energy.

- A. Batteries--Groups of cells which use chemical energy to produce electrical energy.
 - 1. Dry cell--A device such as a flashlight battery (cell) which has chemical energy (electrolyte) in the form of a paste and is enclosed in a case or container and when connected will produce electrical energy.
 - 2. Wet cell--Storage cell. A device which has chemical energy in the form of a liquid (electrolyte) and is enclosed in a container. The wet cell is usually grouped together to produce higher voltage.
- B. Fuel cells--Devices which directly convert chemical energy into electrical energy and thermal energy with water being given off as a byproduct.
 - 1. Hydrox--Hydrogen and oxygen used in many fuel cells.
 - 2. Cathode--The positively charged electrode through which the oxygen passes in the fuel cell.
 - 3. Anode--The negatively charged electrode through which the hydrogen passes in the fuel cell.
- C. MHD (magneto hydro dynamics)--A direct conversion device which uses a moving fluid and a strong magnetic field to produce electrical energy and heat.

D. Chemical rockets--Rockets which combine chemical energy directly into heat energy for propulsion.

1. Hypergolic--Spontaneous combustion when two chemicals are combined producing heat energy.
2. Hydrogen peroxide--A chemical energy source which is used to power both rockets and land vehicles.

TEACHER ACTIVITIES

1. Prepare terminology sheet for students.
2. Gather materials necessary for the construction of a simple fuel cell.
3. Prepare simple diagram with instructions for constructing fuel cell.

STUDENT ACTIVITIES

1. Study terminology sheet and experiment instructions.
2. Match terms to appropriate definitions.
3. Exhibit understanding of chemical energy by constructing a simple fuel cell.

REFERENCES/RESOURCES

Reference:

Walker, John R., Exploring Power Technology, South Holland, Ill.:
Goodheart-Wilcox Co., 1976.

Resources:

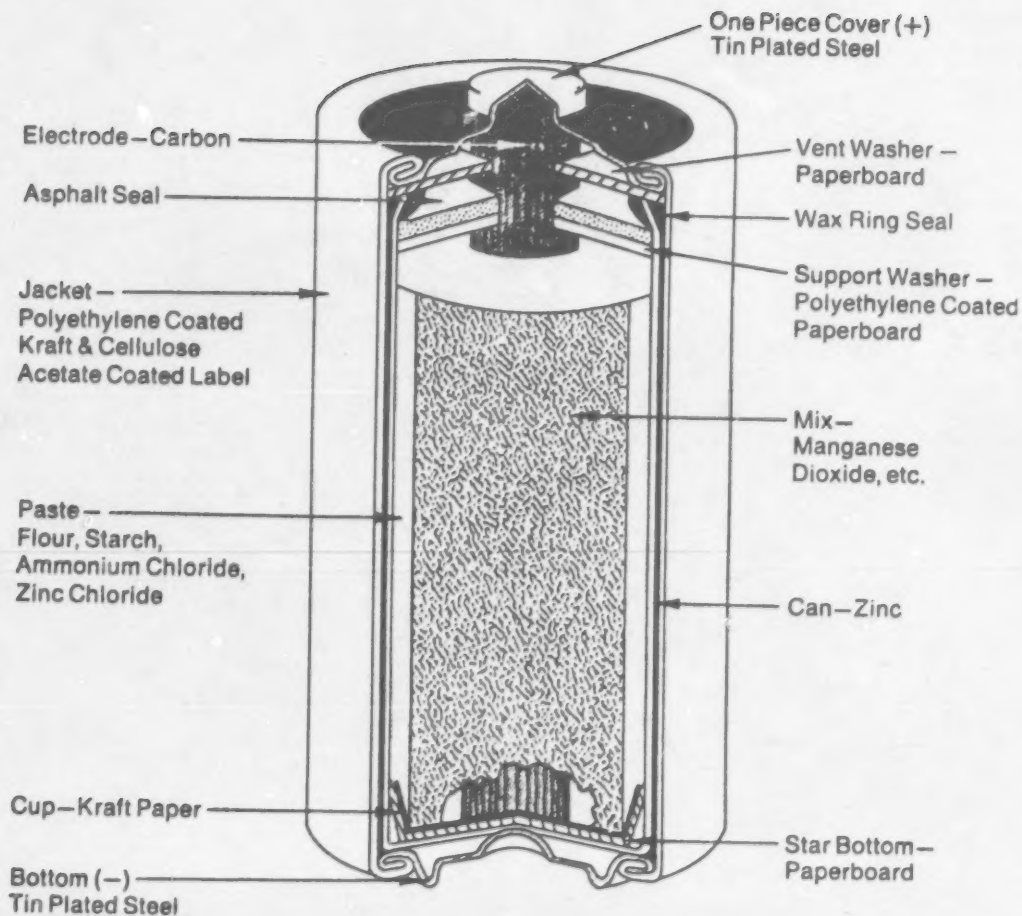
Information Sheets

Demonstration Sheet

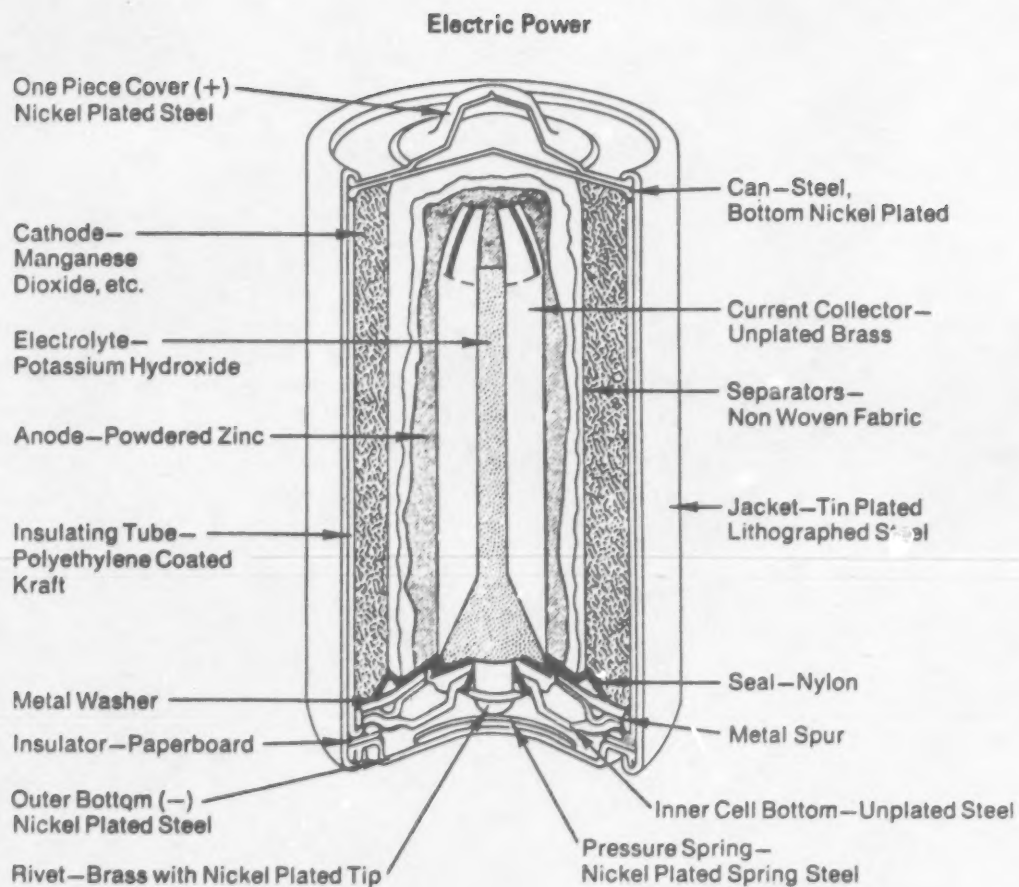
Transparency Masters

Terms and Definitions

1. Cell--An enclosed container which contains chemical energy and converts the energy into electrical energy.
2. Battery--A group of cells connected in such a way as to produce higher voltage or amperage.
3. Dry cell--A device which has chemical energy in the form of a paste electrolyte.
4. Wet cell--A device which has chemical energy in liquid form used to produce electrical energy.
5. Electrolyte--Chemical substance which is used in dry cells and wet cells.
6. Hypergolic--Chemical energy substance which ignites spontaneously when mixed together.
7. Hydrogen peroxide--Chemical energy source which produces heat.



Cutaway of a zinc-carbon standard round cell. (Eveready)



Cutaway of an alkaline cell (primary type). (Eveready)

Construction of Wet Cell
(Storage Type Lead Zinc Cell)

Procedure:

1. Connect one 16 inch wire to the 2" x 4" x 1/8" lead strip.
2. Connect one 16 inch wire to the 2" x 4" x 1/8" zinc strip.
3. Place the lead strip on one side of the wooden spacer block and the zinc strip on the other side of the separator block.
4. Place the two strips with the wooden separator into the glass jar.
5. Make sure the loose ends of the insulated wire are not touching.
6. Carefully add electrolyte to just cover the lead and zinc strips.
7. Allow 3 to 5 minutes for chemical reaction.
8. Attach volt meter to the ends of the insulated wires.
9. Check to be sure you have some reading--it may be necessary to reverse wire connections to indicate positive or negative reading.
10. When reading is recorded, disconnect voltmeter and attach electromagnet.
11. Quickly move pocket compass around one end of electromagnet.

STUDENT ACTIVITY QUIZ

Answer the following questions on the preceding student activity.

1. Indicate voltage reading (how many volts) _____.
2. What happens when you reverse the wire connected to the voltmeter.

3. When the electromagnet is connected the battery will _____

4. What happens when the compass is held close to one end of the electromagnet connected to the cell? _____

5. When the compass is held near the other end of the electromagnetic the hand points _____

6. How far away from the electromagnet does the compass continue to point towards the magnet? _____
7. Use an electromagnet with a greater number of turns and measure the distance. Does the distance increase or decrease? _____
8. How can you improve the cell you have constructed?
 - a. _____
 - b. _____
 - c. _____

ANSWERS TO STUDENT ACTIVITY QUIZ

1. A fully charged commercial cell will produce 2.1 to 2.3 volts.
2. Meter will change direction of reading + or -.
3. Usually increase in chemical reaction.
4. Will point directly toward the end or directly away from the end.
5. Opposite direction from the other end.
6. Measure the distance with a ruler.
7. Increase
8.
 - a. Add more strips of lead and zinc.
 - b. Bore many holes through the lead and zinc strips.
 - c. Connect cells together in series and charge with trickle charges.

EQUIPMENT/SUPPLIES

For construction of a wet type storage cell.

Materials:

1. Glass jar (1 pt. size with large mouth)
2. 1 strip zinc 2" x 4" x 1/8"
3. 1 strip lead 2" x 4" x 1/8"
4. 2 insulated wire strips 16" x 16 ga.
5. 1 pt. electrolyte (sulphuric acid diluted to 10% concentration)
(may be purchased from any auto supply. CAUTION: This chemical is corrosive and may cause burns if it comes into contact with hands or face. Flush with water and clean any spills with bicarbonate of soda.
6. 1 small electromagnet (may be made by winding several hundred turns of small (28 Ga or smaller) enameled magnet wire carefully on a nail or soft iron cone.
7. Small pocket compass
8. Fasteners (clips, screw, bolts or solder)
9. 1 2" x 4" x 1" wood spacer or separator block
10. Voltmeter to test D.C. voltage of cell.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

ENERGY AND POWER

Title of Unit:

NUCLEAR ENERGY

DESCRIPTION OF UNIT

This unit covers the concepts of nuclear energy and nuclear power. The processes of nuclear fission and nuclear fusion are explained. The role of nuclear energy in transportation today and its possible use as a means of transportation for the future are covered. The materials in this unit are designed for 2 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to describe nuclear energy and nuclear power. The student will be able to explain both advantages and disadvantages of nuclear energy. The student will be able to describe the utilization of nuclear energy to provide power for sea transportation. The student will develop an understanding of the occupational and employment opportunities in the field of nuclear power.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. List specific hazards in dealing with nuclear power/energy.
2. Match given nuclear terminology with specific definition.
3. Illustrate by a schematic diagram an understanding of the use of nuclear power in marine transportation.
4. List four possible uses of nuclear power.
5. List three jobs related to nuclear power.

OUTLINE OF CONTENT

I. What is Nuclear Energy

Nuclear energy is energy in the form of radiation and heat when atoms are split apart or combined to form different atoms and energy.

- A. Atom--The basic building block of the elements our universe is made of. The atom is composed of protons, neutrons and electrons.
- B. Protons--Particles of the nucleus (center) of an atom with positive charge.
- C. Neutrons--Particles of the nucleus (center) of an atom with no charge.
- D. Electron--Particle around the outside (shell) of an atom with negative charge.

II. Reactor

A device which is used to control the splitting apart of atoms to form new or different atoms and energy (radiation and heat).

- A. Fission--The splitting apart of atoms (usually uranium) to form new atoms and energy.
- B. Fusion--The combining of atoms (usually hydrogen) into new atoms and energy. (Note: This process is not yet fully developed to produce usable energy except in weapons and in brief laboratory experiments.)
- C. Boiling water reactor--Reactor which uses uranium to produce steam directly.
- D. Liquid metal reactor--Reactor which uses uranium to heat liquid metal (usually sodium or) and employs a heat exchanger to change water into steam as it passes through the heat exchanger.
- E. Breeder reactor--A reactor which converts uranium to plutonium while it is in operation.

III. Nuclear Powered Ships

Ships such as submarines, aircraft carriers and other warships powered by steam generated by nuclear reactors. (Note: Some non-military ships are also nuclear powered.)

TEACHER ACTIVITIES

1. Prepare terminology sheet listing and defining items relevant to nuclear energy and nuclear power.
2. Prepare transparency illustrating basic concepts of nuclear energy and nuclear power.
3. Prepare teacher-made test on concepts of nuclear energy and power.

STUDENT ACTIVITIES

1. Study list of terms applicable to nuclear energy and power.
2. Discuss concepts of nuclear energy and power.
3. Draw a schematic diagram of a nuclear propulsion system.
4. Take Test.

REFERENCES/RESOURCES

Reference:

1. Walker, John R., Exploring Power Technology, South Holland, Ill.: Goodheart-Wilcox Co., 1976.

Resources:

1. Transparency
2. Information Sheets

Terms and Definitions

1. Atom--The smallest unit of an element.
2. Core--The center or heart of a nuclear reactor which contains the radioactive materials.
3. Electron--Particle having a negative electric charge.
4. Fission--The splitting apart of atoms to produce new atoms and energy.
5. Fusion--The combining of atoms to produce new atoms and energy.
6. Helium--A light element which is one produce of hydrogen fusion.
7. Hydrogen--The lightest element used in nuclear fusion.
8. Neutron--Particle having no electric charge.
9. Nucleus--The center of the atom.
10. Plutonium--A man-made radioactive element developed from uranium.
11. Proton--Particle having a positive electric charge.
12. Radiation--Particle or waves of energy.
13. Reactor--A device for controlling nuclear fission.
14. Uranium--A heavy metallic element often used in nuclear fission.

NUCLEAR APPLICATIONS

1. Electric Power Generation

The prime use of nuclear energy is to produce thermal energy (heat) which converts water into high pressure steam. The steam drives a turbine which in turn drives a generator. This produces electric energy which is transported over cables and wires to be used in many ways. One way is to drive commuter train-trolleys and electric buses.

2. Transportation Vehicles

The use of nuclear power in direct transportation is limited. One passenger transport vehicle was commissioned but is now retired because of cost.

Military submarines and surface ships are the main users of nuclear "engines". These are nuclear reactors which produce heat to make steam to drive turbines.

3. Experimental Propulsion

Some nuclear rockets have been tested but no rockets have been used. Jet engines using nuclear reactors have been designed but none have been built.

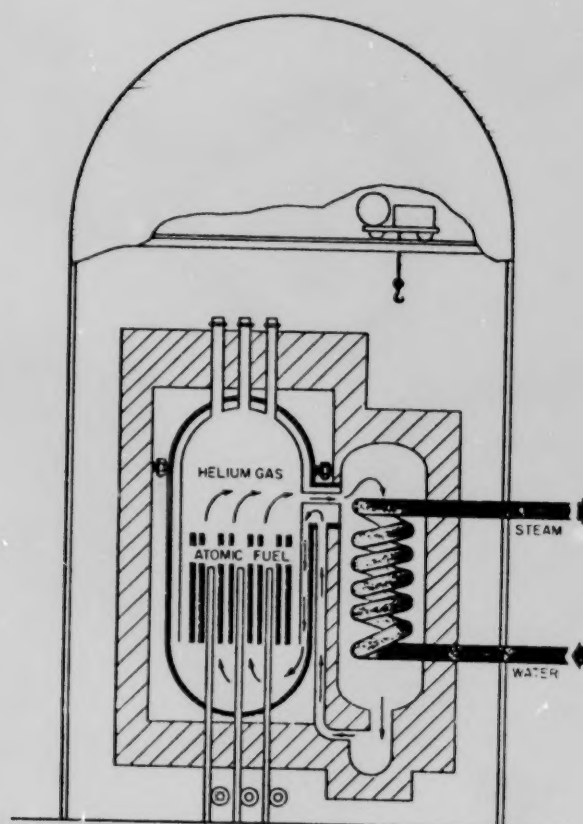
DANGER

RADIATION FROM RADIOACTIVE
MATERIALS CANNOT BE.....

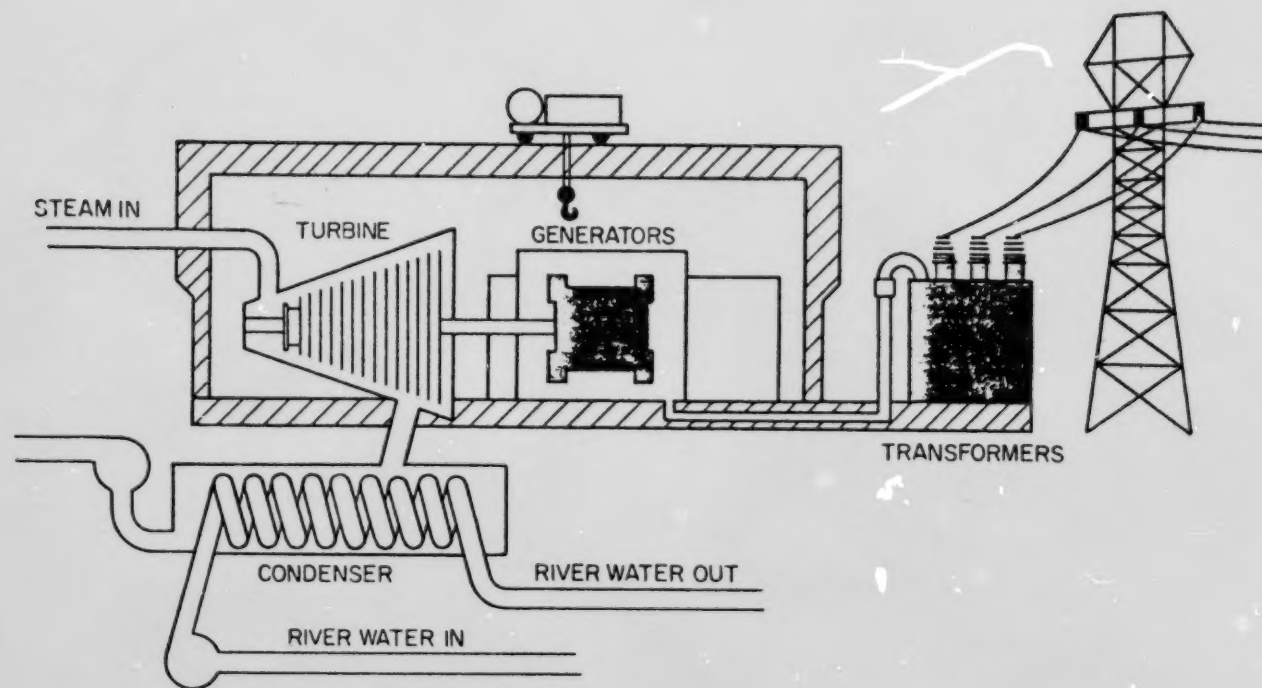
SEEN
HEARD
FELT
TASTED
SMELLED

PROTECT YOURSELF. WEAR
YOUR RADIATION MONITOR.

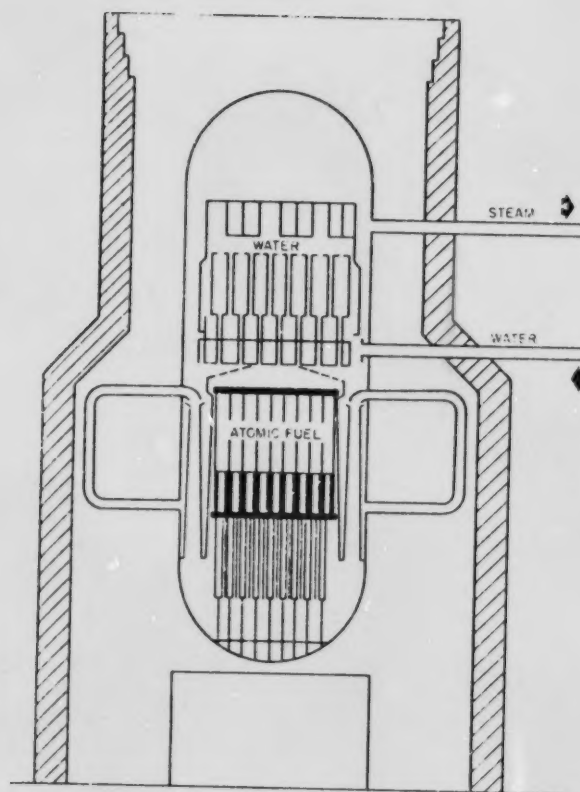
Radiation released by nuclear fission cannot be seen, heard,
felt, tested or smelled. However, it is deadly if not properly used.



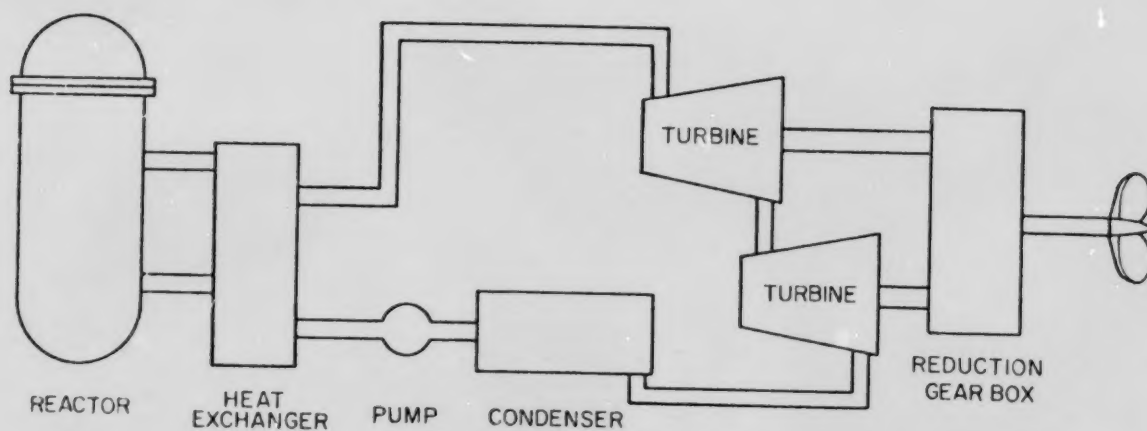
A helium-cooled reactor. (Philadelphia Gas and Electric Co.)



How steam produced by a nuclear reactor is used to generate electricity.



BOILING WATER REACTOR



Schematic diagram showing how nuclear power is used in marine applications to drive submarines and surface ships.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

AIR TRANSPORTATION SYSTEM

Title of Unit:

OVERALL VIEW OF THE AIR TRANSPORTATION SYSTEM

DESCRIPTION OF UNIT

This unit covers the basic air transportation system. It gives you an overview of the several components of the air transportation system and their interrelated functions. The materials in this unit are designed for 5 hours of instruction.

UNIT OBJECTIVE

After the completion of this unit, the student will be able to; describe the operation of the air transportation system, explain why such a system is necessary in this world of rapidly changing technology.

PERFORMANCE OBJECTIVES

After the completion of this unit, the student will be able to:

1. Describe the operations of the air transportation system.
2. Name the three components of the air transportation system.
3. State two advantages of the air transportation system.
4. State two disadvantages of the air transportation system.
5. Explain why passengers must undergo a security check prior to boarding an aircraft.
6. List the articles which are prohibited on an aircraft and tell why.

OUTLINE OF CONTENT

I. What is an air transportation system?

Definition - An air transportation system is a system used to transport goods and people through the medium of air.

II. What are the components of the air transportation system?

- A. The service area, including maintenance services, air traffic controllers, established airways, approach clearances, and weather briefings.
- B. The facility, including airport, terminal building, weather service briefing facility, flight service office, and other support equipment.
- C. The vehicle. (See transparency #1)

III. Why have an air transportation system?

A. Advantages:

- 1. Speed in the movement of people and cargo. *Demo. #1.
- 2. No roadways other than runways are required. This means that the airways can cross mountains, plains, lakes, deserts and oceans with the same amount of ease.

B. Disadvantages:

- 1. Cost of operation to ship people and goods by air systems is greater.
- 2. Fixed wing aircraft must land outside of towns and cities so there must be a way to get goods and people to their final destination. On occasion rotary wing aircraft are used to ferry goods and people to downtown metropolitan areas.

IV. How does the system operate?

People and goods are transported by some land system usually to the airport. There they are ticketed, checked for security, weighed and loaded on the aircraft. A flight plan is filed and the aircraft is cleared to its destination airport by the Federal Aviation Agency. The route of flight will normally be conducted on federally approved airways or international routes over the oceans. At the destination airport the aircraft will make an approved approach followed by a landing. The aircraft will then taxi in to the terminal building and discharge passengers and cargo. If the aircraft is supersonic (faster than the speed of sound), the ocean can be crossed in a matter of two or three hours.

V. Passenger Considerations.

A. Security - Passengers boarding an aircraft have their carry on luggage X-rayed to check for weapons. The passengers themselves must walk through a magnometer to check for carry on weapons. This is to ensure that no terrorist groups or deranged individuals carry on weapons to hijack the aircraft. Why is this so important? Have you ever heard of a bus being hijacked to an overseas location?

B. Safety

1. Briefing - Given by the stewardess as to emergency exits, oxygen masks, flotation gear and instructions to be followed (i.e. "no smoking" and "fasten seat belt" signs.)
2. Prohibited Articles - Pressurized cans, cigarette lighters and matches in luggage. Some items are prohibited because they are illegal; some are prohibited because they present a hazard to flight. (See transparency #2)

AT 1.4

TEACHER ACTIVITIES

- I. Provide student with module.
- II. Make transparencies.
- III. Discuss unit and specific objectives.
- IV. Discuss information sheets and go through outline of material giving demonstrations as you go.
- V. Discuss student activity sheets.
- VI. Give test.
- VII. Plan field trip to airport (suggested)

STUDENT ACTIVITIES

- I. Read objective sheet.
- II. Study information sheet.
- III. Complete activity sheets.
- IV. Take test.
- V. Take field trip. (suggested)

AT 1.6

REFERENCES/RESOURCES

I. References

- A. Misenhimer, Ted G., Aeroscience, Los Angeles, CA; Aero Products Research, Inc., 1976.

II. Resources

- A. Information sheets
- B. Transparency masters
- C. Activity sheets
- D. Demonstrations

Terms and Definitions

Air transportation - The transportation of people and goods by way of aircraft in the interstate, overseas or foreign air systems or the transportation of mail by aircraft.

Airport - An area of land or water that is used or intended to be used for the landing and take off of aircraft, and includes its buildings and facilities, if any.

Aircraft - A vehicle that is used or intended to be used for flight in air.

Airway - A designated and identified roadway in the air through which aircraft fly from one destination to another.

Controlled airspace - Airspace within which no aircraft may fly without the express permission of air traffic control.

Airplane - An engine driven, fixed wing aircraft heavier than air that is supported in flight by the dynamic reaction of the air against its wings.

Airship - An engine driven, lighter-than-air craft that can be steered.

FAA - Federal Aviation Administration is the U.S. government agency which sets up all rules under which aircraft fly within the United States.

Flight plan - Specific information relating to the intended flight of an aircraft that is given orally or in writing to air traffic control.

Air traffic control - A service operated by the Federal Aviation Administration to promote the safe, orderly and expeditious flow of air traffic through ZZ centers which maintain radio and radar contact with all aircraft.

Helicopter - A craft which has a motor driven rotating wing that also provides horizontal motion.

Heliport - An area of land, water, or structure used or intended to be used for the landing and take off of helicopters.

AIR TRANSPORTATION SYSTEM

VEHICLE:

Lighter than air
Fixed wing
Rotory wing

FACILITIES:

Air fields
Terminals
Flight planning facilities
Ground support equipment

SERVICES:

Maintenance
Air traffic control
Airways and approaches
Weather service

211



212

T.M.-2 / ATY 1.7-B

PROHIBITED ARTICLES

CARRY ON LUGGAGE OR ON PERSON

1. HAZARDOUS CARGO - DANGEROUS (Note 1)
2. AMMUNITION - DANGEROUS
3. GUNS AND/OR KNIVES - ILLEGAL (Note 2)
4. ILLEGAL DRUGS - ILLEGAL
5. STOLEN GOODS - ILLEGAL

CHECKED BAGGAGE

1. HAZARDOUS CARGO - DANGEROUS
2. AMMUNITION - DANGEROUS
3. ILLEGAL DRUGS - ILLEGAL
4. STOLEN GOODS - ILLEGAL

NOTE 1. WHEN CARRYING CARGO WHICH COULD BE LISTED AS HAZARDOUS, CHECK WITH THE SENIOR AIRLINE OFFICIAL PRESENT FOR A RULING. SUGGESTED ARTICLES WHICH SHOULD NOT BE PLACED IN CHECKED BAGGAGE ARE MATCHES, CIGAR LIGHTERS, LIGHTER FLUID, GASOLINE AND PRESSURIZED CANS.

NOTE 2. GUNS AND KNIVES MAY BE CARRIED IF THEY ARE IN THE CHECKED LUGGAGE.

THE COST AND SPEED OF AIR TRANSPORTATION

Objective:

To show the students the time required to move people and goods from one place to another by the use of the air transportation system. Also, the cost in money for this movement will be greater using the air transportation system. Students should be made to realize that time is money, therefore it is not necessarily less economical.

Materials

1. Six airline schedules to a given destination.
2. Six bus schedules to the same destination.
3. Make copies and use the hypothetical schedules which are attached.

Procedure

1. Divide the students in groups of four.
2. Pass out one airline schedule and one bus schedule to each group of students.
3. Show the students how to look up the departure time and arrival time at each destination. Compare the times.
4. Show the students how to look up the price of the ticket to the destination. Compare the costs.

AT 1.9

BLUE TICK BUS SCHEDULE

SCHEDULE

ARRIVE/DEPART	DESTINATION	COST
ORIGINATE / 7:40 AM	Memphis	-----
9:40 AM / 10:00 AM	Jackson	\$ 8.00
2:00 PM / 2:15 PM	Nashville	\$16.00
6:30 PM / 7:00 PM	Chattanooga	\$14.00
9:50 PM / 10:00 PM	Knoxville	\$11.00
1:00 AM / TERMINATE	Bristol	\$12.00

AT 1.10

WINGWAY AIRLINES

SCHEDULE

Flight No.	ARRIVE/DEPART	DESTINATION	FARE
740	ORIGINATE / 7:40 AM	Memphis	-----
740	8:10 AM / 8:30 AM	Jackson	\$20.00
740	9:05 AM / 9:20 AM	Nashville	\$40.00
740	9:45 AM / 10:00 AM	Chattanooga	\$33.00
740	10:20 AM / 10:30 AM	Knoxville	\$30.00
740	11:00 AM / TERMINATE	Tri-Cities	\$27.50

TRIP PLANNING

Objective:

You will take the materials given and correctly complete the following task:

1. Plan a trip of 150 miles or more on a bus. Be sure the city is also served by an airline.
2. Compute the time you will spend on the bus.
3. Compute the cost of the bus ticket.
4. Plan a trip to the same city on an aircraft.
5. Compute the time you will spend on the aircraft.
6. Compute the cost of the airline ticket.

Materials:

1. One airline schedule to a city 150 or more miles away.
2. One bus schedule to the same city 150 or more miles away.

Procedure:

1. Determine the city from which you will start your trip.
2. Determine the city at which your trip will terminate.
3. Use the airline schedule and determine the departure time at your origin.
4. Use the airline schedule and determine the arrival time at your destination. If you have a stop-over, repeat steps 3 and 4 for each step.
5. Subtract departure time from arrival time to obtain total hours of travel time. Hint: If your departure time is before noon and your arrival time is after noon, add 12 hours to the afternoon time. Record the total time.
6. Check the schedule for the cost of the fare. Write it down.
7. Use the bus schedule and determine the departure time at point of origin.
8. Use the bus schedule and determine the arrival time at your destination. If you have a stop-over, repeat steps 7 and 8 for each stop.

9. Subtract departure time from arrival time to obtain total hours of travel time. See step 5. Record the total time.
10. Check the schedule for the cost of the fare. Write it down.
11. Compare the total time spent and cost of the fare found in steps 3 through 6 with the travel time and cost of the fare found in steps 7 through 10.
12. Write a short paragraph about the trip as if you plan to take it and specify the mode of transportation. Be sure to explain why you selected the mode you did.
13. Turn the paper in to your instructor.

UNIT TEST

1. A system which carries goods and people on vehicles that travel through the media of air is called a/an:
 - a. Airborne carrier system
 - b. Cargo craft system
 - c. Air transportation system
 - d. Railway
2. Before a person is allowed to board an aircraft, he must be screened through a device called a/an:
 - a. X-ray machine
 - b. Magnometer
 - c. Floroscope
 - d. Sieve
3. Carry on luggage is passed through an X-ray machine to check for:
 - a. Guns and Knives
 - b. Drugs
 - c. Confidential material
 - d. Lewd magazines
4. Safety briefings are given to the passengers by:
 - a. Pilots
 - b. Maintenance men
 - c. Ticket agents
 - d. Stewards or Stewardesses
5. The three major areas of the air transportation system are:
 - a. Service, facility and vehicle
 - b. Vehicle, airplanes and pilots
 - c. Airports, runways and towers
 - d. Tow trucks, ramps and pilots
6. One advantage of the air transportation system is:
 - a. Cost
 - b. Speed
 - c. Weight
 - d. Balance
7. One disadvantage of the air transportation system is:
 - a. Airplanes must land outside of towns.
 - b. Airplanes require a long run to take-off.
 - c. You don't have to build roads for the airplanes.
 - d. Airplanes crash more than trucks wreck.
8. Two articles which are prohibited on aircraft because they are illegal are:
 - a. Cigarette lighters in suitcases
 - b. Matches in your pocket
 - c. Marijuana and stolen goods
 - d. A hunting knife in your checked luggage

9. Most aircraft travel from one place to another over federally designated:
 - a. Roads
 - b. Taxiways
 - c. Airlines
 - d. Airways
10. A rotorcraft which, for its horizontal motion, depends principally on its engine driven rotors is called a/an:
 - a. Autogyro
 - b. Gyrocopter
 - c. Helicopter
 - d. Dirigible

ANSWERS TO TEST

1. c
2. b
3. a
4. d
5. a
6. b
7. a
8. c
9. d
10. c

MATERIAL LISTING

1. Twelve bus schedules from your town to a major city at least 150 miles distant. Use Greyhound or Trailways.
2. Twelve airline schedules from your town to the same major city listed in item 1. Use any airline which serves that city.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

AIR TRANSPORTATION SYSTEM

Title of Unit:

FACILITIES

DESCRIPTION OF UNIT

This unit will cover the facilities needed to support the air transportation system. It will explain to you all the various pieces of equipment and support facilities needed to move goods and people from one place to another by utilizing the air transportation system vehicles. The materials in this unit are designed for 15 hours of instruction.

UNIT OBJECTIVE

After completion of this unit, the student will be able to describe the layout of an airfield, name the different support equipment required and list the navigational facilities. He will also be able to state the function of the navigational facilities and state why they are necessary to support the air transportation system.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. Describe the runway layout on an airfield.
2. Describe runway lighting.
3. Name the various pieces of support equipment found on the airfield.
4. List the navigational facilities.
5. Describe a wind sock and/or tetrahedron.
6. Explain the purpose of the control tower.
7. State the purpose of the rotating beacon and list the codes.
8. State the safety rule associated with the fueling of aircraft.

OUTLINE OF CONTENT

I. Facilities

- A. Terminal building--The building used to house the passengers and cargo awaiting to be on-loaded or off-loaded.
 - 1. Ticket counter--Most airlines have ticket agents to book passengers on the aircraft and pick up luggage.
 - 2. Restaurant area--Self explanatory.
 - 3. Waiting area--The area where passengers wait to board the aircraft. Most airlines have an agent in this area to take tickets and issue boarding passes.
 - 4. Security screening area--An area where passengers are screened prior to boarding.
 - 5. Gift shop area--An area where gift shops are located for the convenience of the traveler.
 - 6. Baggage pick-up area--An area where baggage from the incoming flights is picked up. Usually this is an automated turntable which holds the bags as they're off-loaded. Large terminals have several turntables and they're designated by flight number.
- B. Control tower--A tall structure usually enclosed in glass from where an observer can see the entire airfield. It is used to house the control tower operators. They issue landing, take-off, and taxi instructions to aircraft.
- C. Boarding ramps
 - 1. Terminal attached--Loading ramps which extend from the passenger waiting area to the aircraft. These ramps are moveable in that they swing back and forth. They are mounted on wheels and are driveable by an operator. They extend to the aircraft and provide a weatherproof entrance and exit for the passengers.
 - 2. Self-contained--These loading ramps are carried in the aircraft and are used in open areas or areas where no terminal attached ramps are present.
 - 3. Mobile boarding ramps--These loading ramps are capable of being moved any place on the field. They remain on the airfield and are used when no terminal attached or self-contained boarding ramps are available.

D. Support Equipment

1. Gas trucks--Used to carry Avgas (Aviation gasoline) and JP Fuel (Jet fuel) to aircraft. (CAUTION: "No Smoking" within 50 ft.)
2. Oil trucks--Used to carry engine oil to the aircraft.
3. Tow trucks--Small tractors used to tow the aircraft on the field if no pilots are available to use the aircraft engines.
4. Baggage train--A tow tractor with several trailers to haul baggage and cargo to the aircraft.
5. Food service truck--A truck used to carry portion-controlled food trays and beverages to the aircraft for on-loading food.
6. APU--Auxiliary power unit used to supply electrical power to the aircraft when the engines are shut down and passengers are still on the aircraft. Some aircraft contain their own small auxiliary power units and run constantly to provide electrical power when the main engines are shut down.
7. Air conditioning and heating unit--A portable or mobile unit to provide creature comfort when the main aircraft engines are shut off and the aircraft is on the ground.

E. Landing and taxi areas

1. Runways--The strip where the aircraft lands and takes off. They can be sod, gravel or hard-surfaced. (Transparency #1)
 - a. Orientation--The numbers on the runway signify the magnetic heading of the runway.
 - (1) Compass rose--The compass rose is not a landing area but it is a turntable on which an aircraft can sit and turn to check its compass. This must be done at periodic intervals.
 - b. Lighting and marking
 - (1) Threshold--The edge of the runway just before the touchdown point. At night the runway threshold is marked with lights.
 - (2) Touchdown point--Just beyond the threshold. It is not marked.
 - (3) Center line--A line down the center of the runway. At night, it can be marked by a line of lights.

- (4) Side lights--White lights down either side of the runway to mark the edge.
 - (5) Runway end identifier lights--Lights installed at some airports to provide rapid identification of the approach end of the runway. This system is made up of a pair of synchronized flashing lights located on each side of the runway facing the approach area.
- c. Wind indicators--Devices located on the airfield to show the direction of the wind.
- (1) Wind sock--A sock on a pole. Some wind socks are able to tell speed of the wind due to the degree of erect status they attain.
 - (2) Wind tee--Shows direction.
 - (3) Tetrahedron--Shows direction. A 4-sided figure, usually very large and driven mechanically.
 - (4) Anemometer--A small three/four cup wheel usually located on the control tower. It is used to tell wind speed.
2. Helicopter landing area (Transparency #2)
- An area where helicopters land and take off vertically. Helicopters also can use the regular fixed wing landing area and make rolling take offs and landings.
3. Taxiways--The area that an aircraft taxis on the ground under its own power. At night the taxiways are marked with blue lights.
4. Airport lighting--Lights and rotating beacons used to locate an airport or seadrome.
- a. Civil airport--A rotating green and white flash alternating signifies a civil airport with night landing facilities.
 - b. Military airport--A rotating green and double white flash alternating signifies a military airport with night landing facilities.
 - c. Seadrome--A rotating yellow and white alternating flash indicates a seadrome with night landing facilities.

F. Flight planning and meterology

An area located below the control tower usually where pilots can fill out and file flight plans and check the weather enroute prior to the flight. The airport manager is also located in this area. Flight service stations and FAA centers coordinate from this area to guard the flight. (Demo 2)

G. General aviation area

The area on the airport where small private aircraft land and are hangered.

1. Fixed base operators--An area where charter service and flight training areas are located. Some provide maintenance service.

2. Aircraft sales area.

H. Navigational facilities - (Demo 3)

1. Introduction

Navigation has always presented a problem relating to movement from one point to another. If we know exactly where we are, the route we want to take and the place we want to go, then our navigation problem is solved. On land we use a system of markers to designate highways and roadways. On water, however, we must determine our location by use of the stars, etc. since no roadway markers exist. In the air, a problem even greater did exist at one time. In the past airways or roadways in the sky over land were designated by rows of flashing lights spaced at intervals between points. The pilot used strictly his visual senses to fly from light to light and on cloudy days had to either stay at home or be able to fly under the clouds where he could see the lights. As time went on and radio was invented and improved upon, the radio range was invented. The radio range was a method that transmitted a radio signal by using the A (.-) of Morse Code and the N (-.) of Morse Code. When the pilot was on course, he could hear both the A (.-) and the N (-.) at the same time. When this occurred, a steady buzzing sound was heard in the pilot's earphones. (See transparency #TM-4). If the pilot heard an A or an N, he knew he was off course, and corrected accordingly. The pilot was now navigating by sound and he could successfully fly in the clouds without seeing the ground, from hence came the term flying blind. His eyes had now become his ears, (Demo. III 3). These facilities have for the most part become extinct. They did serve their purpose in the past but are not very effective for today's high speed jets. The light towers could only be used on clear days at low attitude and slow speeds. The radio range was effective but it was transmitted over low frequency radio carrier waves. Consequently, thunderstorms, sunspots, and other magnetic interferences provided static which caused many problems.

Later on, the VOR station was invented. This station transmitted an electronic signal on very high frequency radio waves which eliminated the problem with static. Also the VOR receiver in the cockpit gave a display to the pilot so he could now follow a course by looking at an indicator which showed him whether or not he was on course. Now the pilot was electronically able to see the course on the ground. (See transparency T.M. 5). Other pieces of equipment helped the pilot more. TACAN can not only tell a pilot whether or not he is on course, but also how far he is from the station or fix. Other electronic stations covered here either show a pilot his course line or locate his position on the course line.

2. VOR stations--A VHF omni range. This station emits a very high frequency signal and is used for the orientation of airways. These stations show course lines.
3. TACAN stations--Abbreviation is for Technical Air Navigation and is usually incorporated with the VOR stations but works on a different frequency and is selected by channels. It also utilizes DME (Distance Measuring Equipment) and can give a read-out of miles to or from the station. This display is provided to the pilot in the cockpit. These stations give course lines and positions along the line.
4. LF Homer or low frequency homer--By using a needle in the cockpit in conjunction with a loop antenna, the direction is pointed to a station. Sometimes selected commercial low frequency AM radio stations are used as homers. These stations show course lines.
5. ILS stations or Instrument landing systems--These stations are located at the end of the main runway on an airport. They provide the pilot with information to make an approach to an airfield on a rainy, cloudy day. They work on the very high frequency range and provide the pilot with both course and glide slope information.
6. Marker beacons--Are fixed stations located along the airway or used in conjunction with the ILS station. These stations are used to provide a definite fix along the course line to an aircraft. They emit a signal over a set frequency and are detected by a blinking light and audio signals in the cockpit. When used in conjunction with an ILS System, as many as three markers can be used. They are called outer middle and inner. At the outer marker, the aircraft begins his descent to a landing, the middle marker provides a cross check of altitude and distance covered. The middle markers are rarely used. The inner marker indicates that the pilot take over visually for landing. If he does not see the runway environment at the inner marker, he must immediately initiate a wave-off and proceed to a safe altitude for another approach or go to his alternate airport.

7. GCA unit or Ground controlled approach radar--The GCA is a radar unit which is orientated around a runway and an operator inside actually talks the pilot down by providing him with course and glide slope information. These units are very portable and are most commonly used by the military.

TEACHER ACTIVITIES

- I. Provide student with module.
- II. Make transparencies.
- III. Discuss Unit and Specific Objectives.
- IV. Discuss Information Sheets and go through Outline of Material giving Demonstrations as you go.
- V. Discuss Activity Sheet.
- VI. Supervise Student Activities.
- VII. Give test.
- VIII. Screen and grade Student Activities. Retain the best ones for use in the next unit.

STUDENT ACTIVITIES

- I. Read Objective Sheet.
- II. Study Information Sheets.
- III. Complete Activity Sheet.
- IV. Take Test.

REFERENCES/RESOURCES

I. References:

Misenhimer, Ted G., Aeroscience, Los Angeles, Ca.; Aeroproducts Research, Inc., 1976.

II. Resources:

- A. Information Sheets
- B. Transparency Masters
- C. Activity Sheets
- D. Demonstrations

Terms and Definitions

Non-directional radio beacon (NDB)--Is a low or medium frequency beacon which transmits non-directional signals. These facilities operate on a frequency band of 200 to 415 kilohertz (kilocycles). AM radio stations are also used for this purpose. The homing equipment is located on the aircraft and can be used to point to the station. It shows the pilot's course line information.

VHF omnidirectional range (VOR)--Are the primary navigational facilities now in use. They operate on very high frequency band of 108.00 megahertz (megacycles) through 117.95 megacycles. The word omni is Latin which means all. Transmissions are line of sight and the effective range at 1000 feet altitude is about 40-45 miles. It shows the pilot's course line information.

TACAN--Stands for Tactical Air Navigation and was developed primarily for military use. Combination with a VOR station results in the station being referred to as a VORTAC. It shows the pilot's course line information and locates his position on the course line.

Marker beacon--Transmits on 75.00 megahertz. The receiver in the aircraft is tuned constantly to this frequency and provides both an audio (beeping) signal and a visual (flashing light) signal in the cockpit. It shows the pilot's his position on a course line only.

Air navigation facility (NavAid)--Any facility used in, available for use in, or designed for use in aid of air navigation, including landing areas, lights, any apparatus of equipment for disseminating weather information, for signaling, for radio-direction finding, or for radio or other electronic communication, and any other structure or mechanism having similar purpose for guiding or controlling flight in the air or the landing or take-off of aircraft.

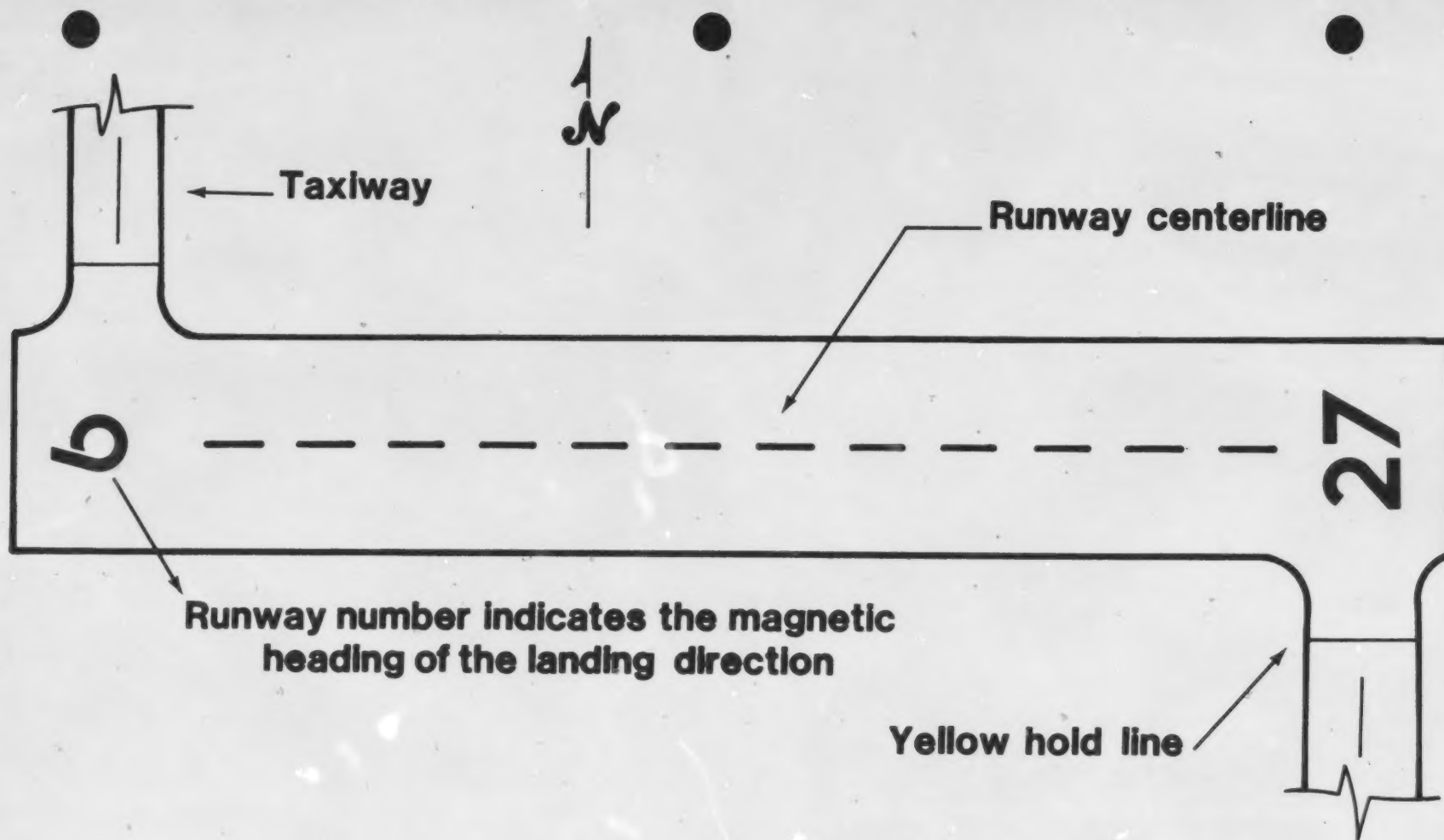
Air traffic--Aircraft operating in the air or on an airport surface exclusive of loading ramps and parking areas.

Course--The intended direction of flight in the horizontal plane.

Distance measuring equipment (DME)--Equipment (airborne and ground) used to measure in nautical miles, the distance of an aircraft from a navaid.

Flight plan--Specified information relating to the intended flight of an aircraft that is filed orally or in writing with the air traffic control facility.

Hertz--Cycle per second.

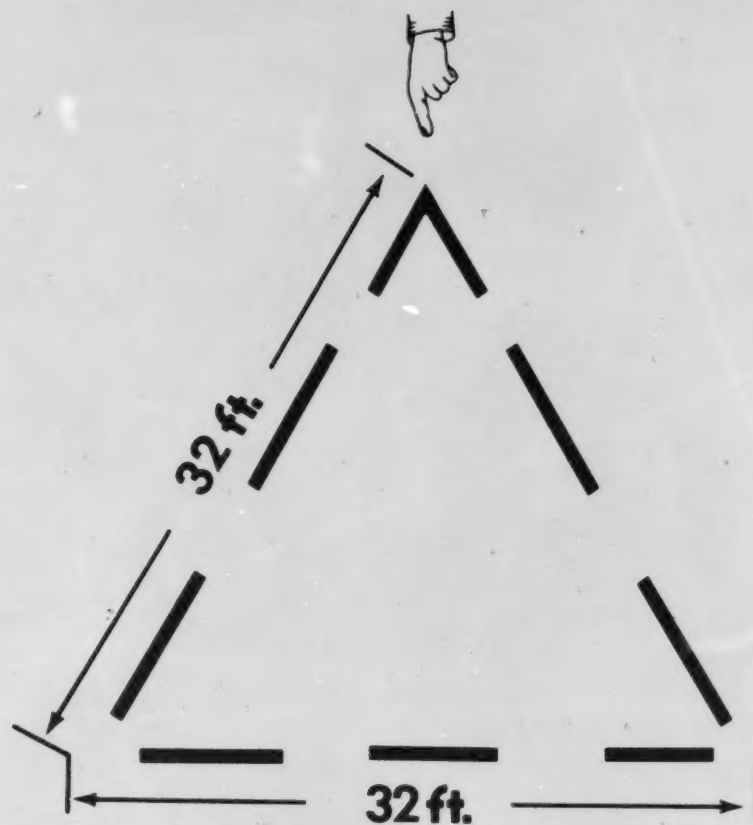


BASIC RUNWAY

235

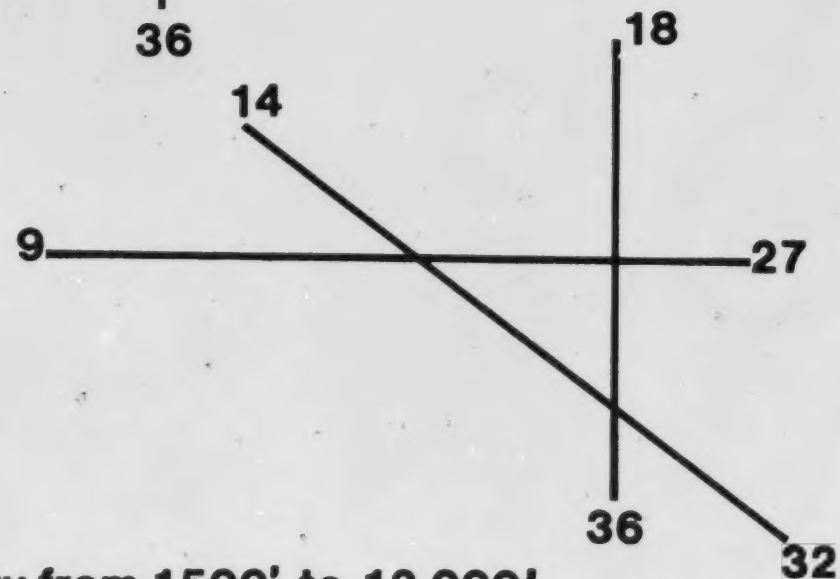
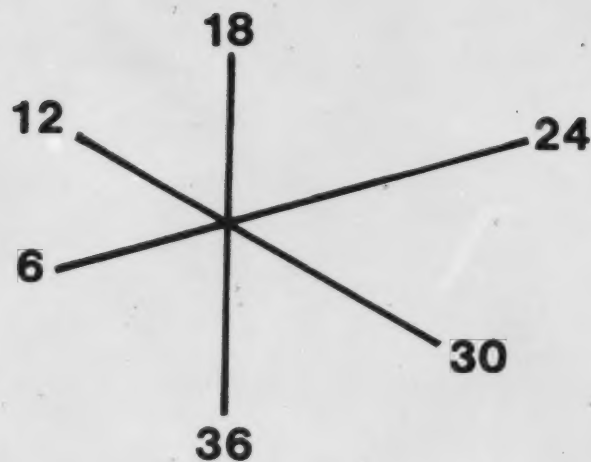
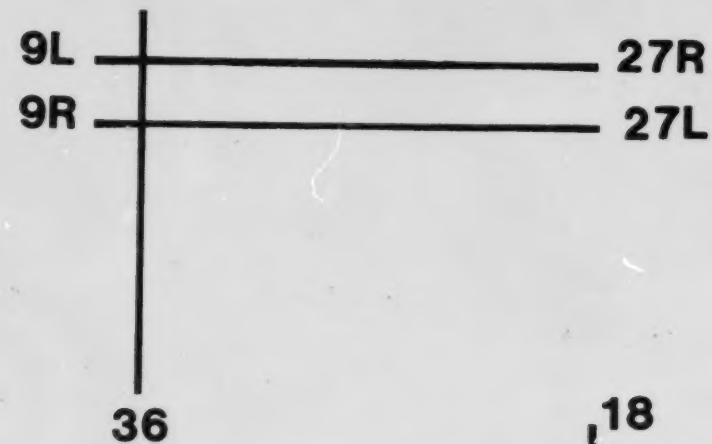
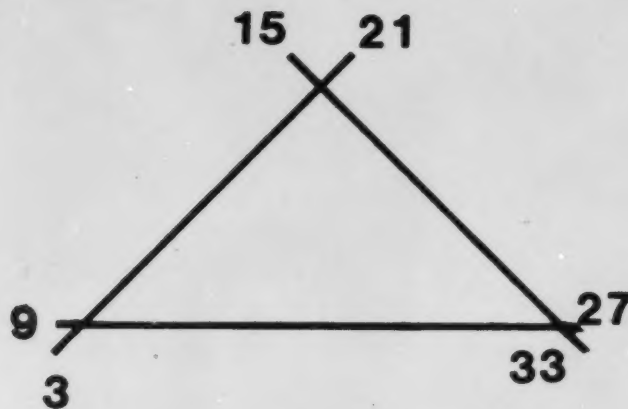
236

**Closed end of triangle
always points to magnetic north**

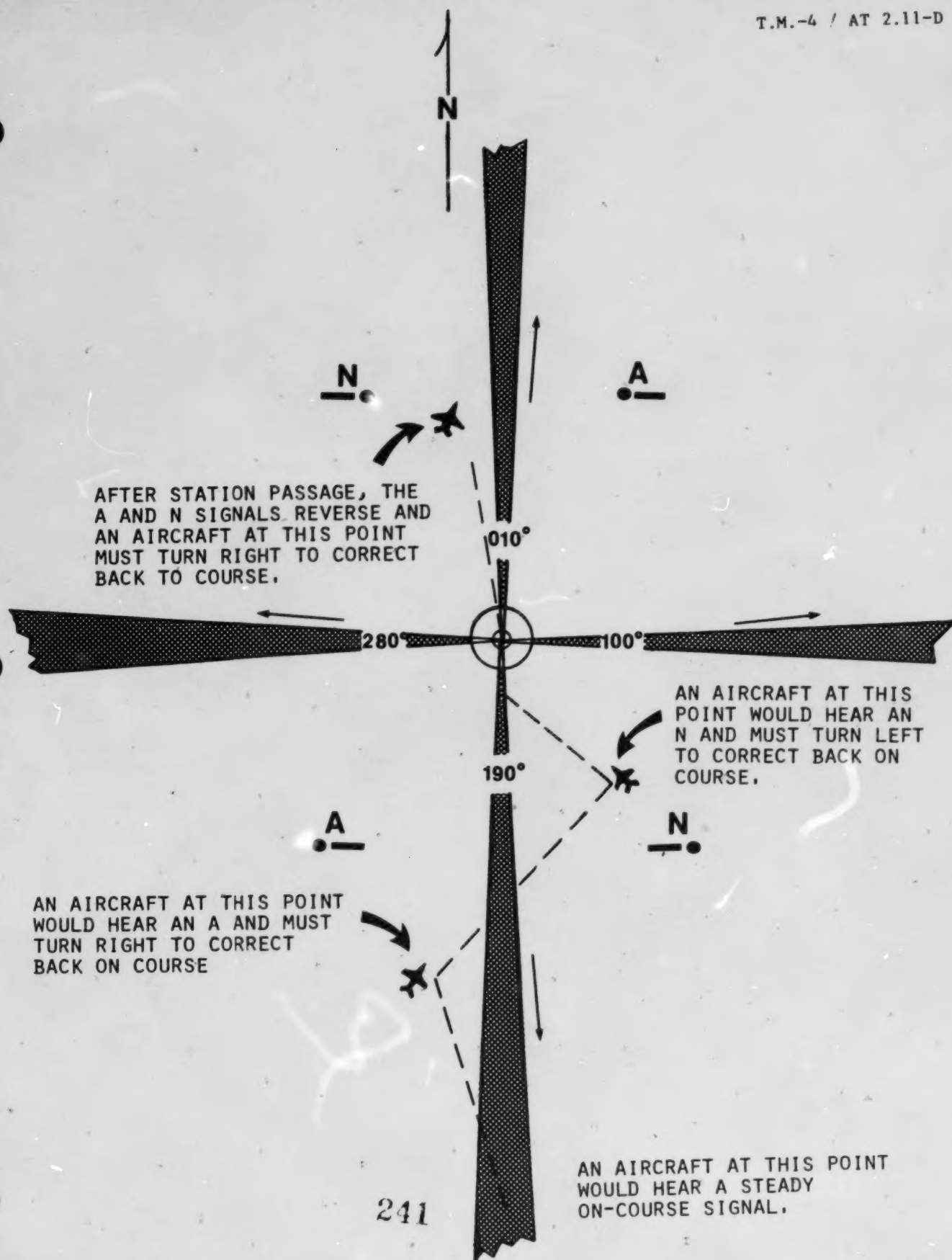


HELICOPTER LANDING AREA

SOME POSSIBLE RUNWAY LAYOUTS



Note: Runways can vary from 1500' to 13,000'
Width varies from 50' to 300'



THE RADIO RANGE

COURSE
OF FLIGHT

VOR 1

VOR 2

VOR 3

COURSE OF
DISASTER

COURSE OF SAFETY

POINT OF IMPACT

ELEV. 25000

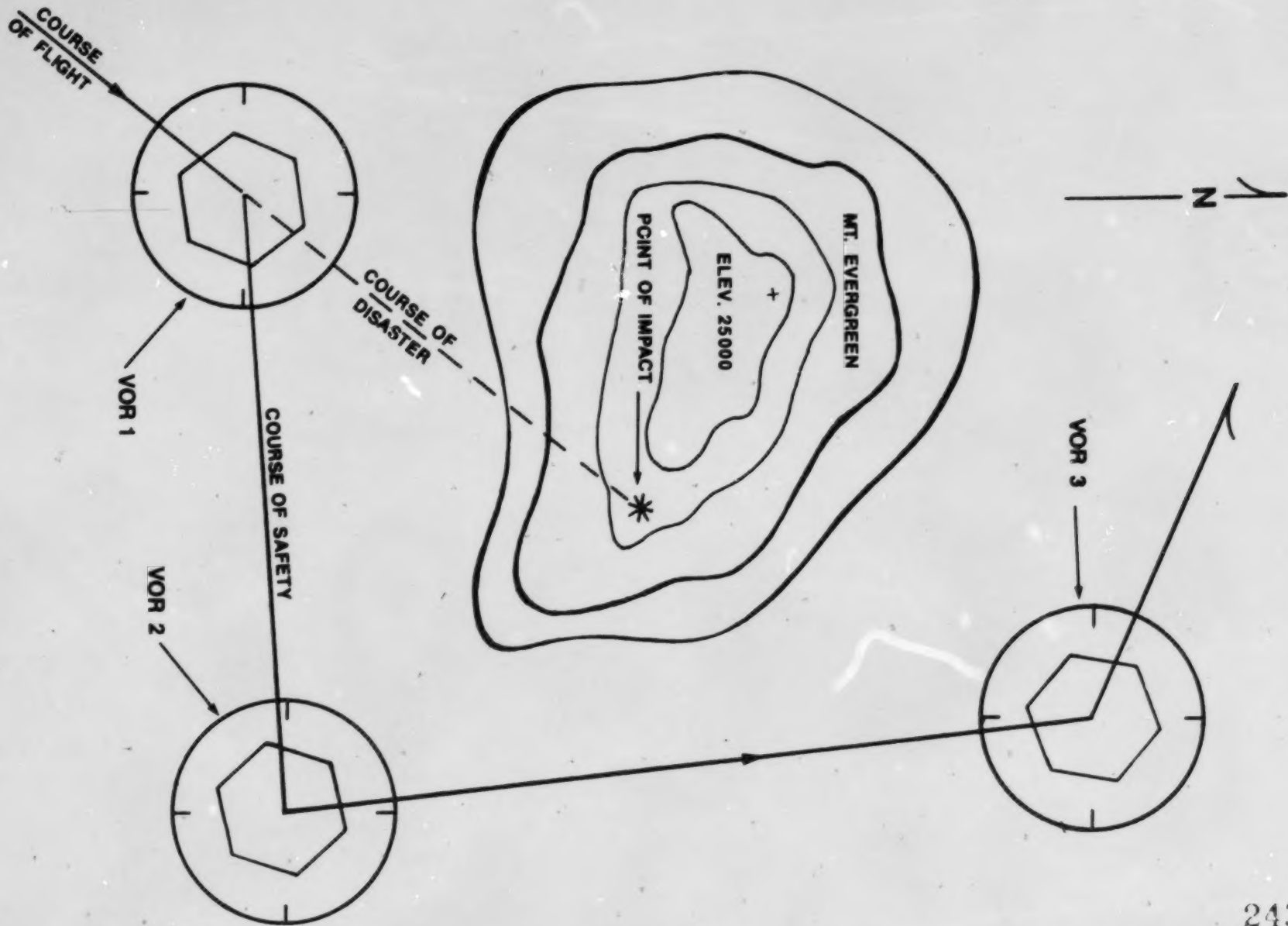
MT. EVERGREEN

N

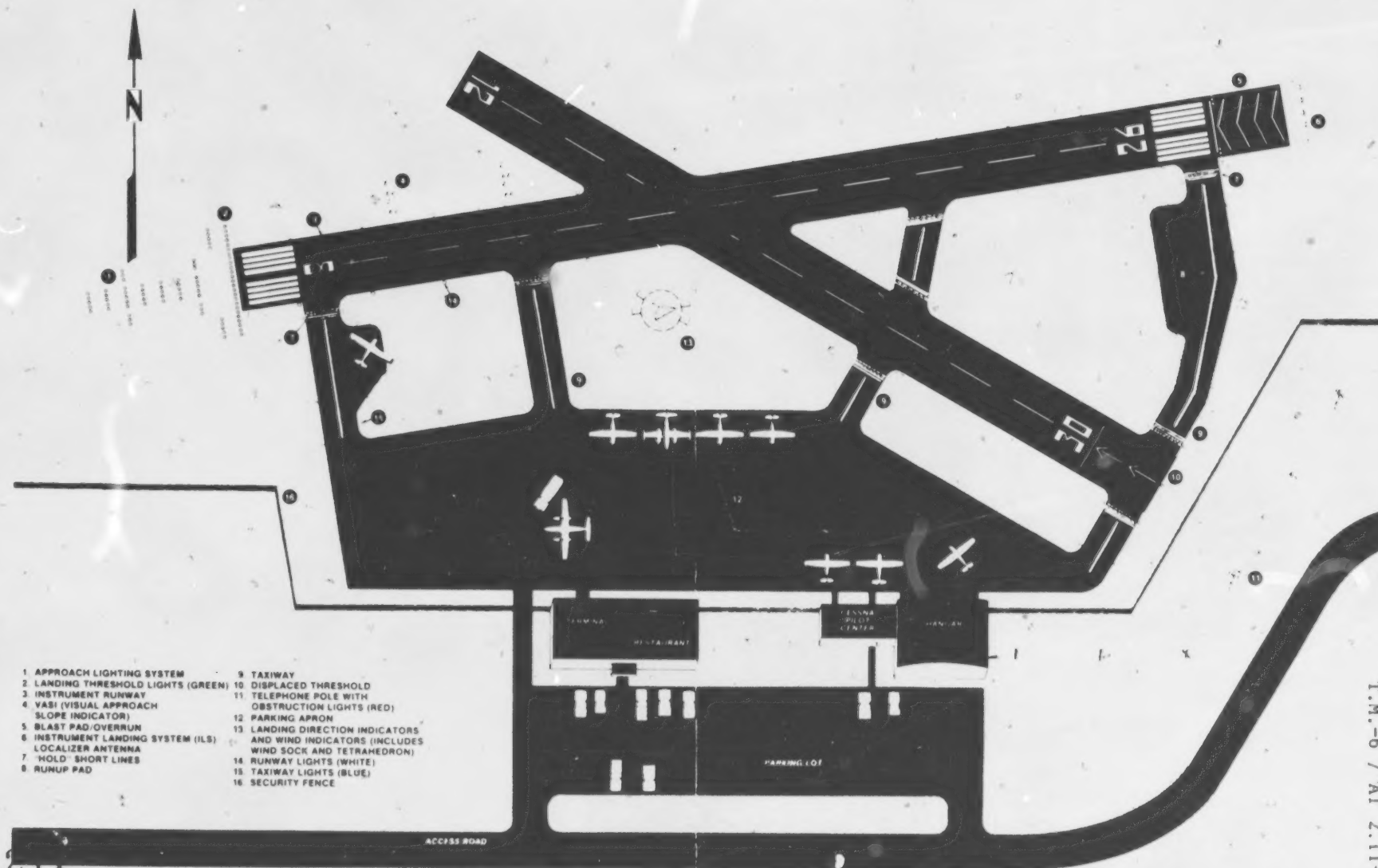
242

243

T.M.-5 / AT 2.11-E



Community Airport Orientation:



COURTESY OF CESSNA AIRCRAFT COMPANY/AIR AGE EDUCATION DEPARTMENT

Demonstration #1

The Magnetic Compass

Objective:

To show the students how to use a compass and the relationship of directions to the earth's surface. This is important since they must know how to orientate themselves to magnetic north. North should be located in the classroom, and marked off by using a masking tape arrow on the floor for use during the remainder of this section on Air Transportation. Use azimuth technique instead of bearing.

Materials:

1. One compass (magnetic)
2. One compass (drafting or chalkboard)
3. 24 sheets of paper
4. 6 small compasses for drawing circles on paper
5. 6 straight edges
6. Masking tape

Procedure:

1. Draw a large circle on the chalkboard.
2. Orientate North (magnetic) toward the top.
3. Mark off headings around the circle in 10 degree increments. Label them from 0° through 350°.
4. Have the students draw a relatively smaller circle on their paper and do the same as step 3.
5. Locate magnetic North with the magnetic compass.
6. At some convenient place on the floor make an arrow out of masking tape pointing to the magnetic North.

(Note: If the building is made of steel and concrete, it may be necessary to go outside to locate magnetic North, since such a mass will distort the magnetic lines of force which pass through it.)

AT 2.13

7. Let the students align their compass rose with the North arrow on the floor.
8. Let the students now point out the direction of travel for the four cardinal headings.
9. Ensure that the students understand the North arrow on their paper must align with the North arrow on the floor in order to find the correct heading.
10. Decide and advise students whether you want them to do Activity II A or II B at this point. Once the concept of Electronic Navigation is understood only part C may be copied and placed on the floor to locate a VOR station.

Demonstration #2

Flight Planning
("Map Reading")

Objective:

To have the students think in terms of planning their trip prior to departure. This demonstration will be done prior to the use of aerial maps through the use of road maps. Have the students fill out the enroute log and plan. Most students are familiar with a road map.

Materials:

1. 7 road maps of your area
2. 24 enroute logs
3. 24 route plan sheets

Procedure:

1. If possible, make a transparency of the area around your town using a state map from a local service station.
2. Divide the students up into groups of 4.
3. Plan a trip from your town through at least 4 more towns. This can be straight line or round-robin.
4. Look up route numbers and mileage.
5. Fill out enroute logs.
6. Complete a route plan sheet.

ENROUTE PLANNING LOG

From	To	Route	Distance	Time Enroute	Total Time

Note: Estimate your average speed to be 40 Miles per hour.

ROUTE PLAN SHEET

Type of car	Your Speed	Distance (Total)	Departure Point	Proposed Departure Time
Route you will travel:				Actual Departure Time
Your Destination	Travel Time (Total)	Your Name		
Total Gas Capacity 21 Gallons	Amount of Gas to be used	Amount of Gas Remaining at Destination (in hours)		

Estimate your car gets 20 Miles per gallon and will consume 2 Gal. per hour.

Understanding the VOR

Objective: To show students the function of a VOR station in the Air Transportation System by using the visual and audio capabilities of the students.

Materials:

1. Three chairs side-by-side in the middle of the floor.
2. A team of four students.

Procedure:

1. Make sure there is a clear area in the room or outside if more convenient.
2. Arrange the chairs in a row within the demonstration area.
3. Arrange three of the students for the team in a triangle but be sure the chairs cross the side of the triangle between students 1 and 3. (Refer to the enclosed graphic representation).
4. Have the 4th student start at student 1, walk to student 2, to student 3 and back to student 1. Note that the student walks around the chairs. Do not let the student climb over the chairs at this time. Explain that the chairs are a mountain peak that reaches 30,000 feet. The walking student is in an airplane that goes only to 20,000 feet. Airplanes cannot fly through granite.
5. Blindfold the student who was doing the walking.
6. Rearrange the pattern of the student triangle but leave the chairs in tact.
7. Have the blindfolded student now start at student 1 and walk to student 3 by walking around the triangle. Note that it cannot be done. Caution should be exercised to be sure the walking student does not fall over the chairs.
8. Repeat step seven but before the walk is started turn the blindfolded student two or three times one way and then the other to thoroughly confuse him. When the student starts to walk, student No. 2 starts to say a steady beep-beep-beep etc. As soon as the walking student reaches student No. 2, student No. 3 starts to say a steady beep, beep, etc. and student No. 2 stops. The blindfolded student safely walks to student No. 3. Note how easily the student walks around the triangle to student No. 3

9. After the student reaches No. 3, have him remove the blindfold.

Principle involved:

Note how the student found his position at student No. 3 by following sound. He was steered around the chairs by following a beam of sound. In order to walk from student No. 3 to student No. 1, the blindfolded student has five alternatives; those alternatives are: (1) have a bridge over the chairs and use it to walk to student 1 by following his steady beep, beep (an airplane that will fly higher), (2) go back the same way he came by following student No. 2's beep-beep (take the same route of flight for return), (3) add a fourth student (another VOR station and take an alternate route), (4) stay where he is until he can see and walk around on the chairs on his own (fly by Visual flight rules) or (5) walk into the chairs blindfolded and fall (crash the airplane into the mountain and be killed). The beeping students are the VOR stations.

Aircraft must fly under all types of weather conditions. On a clear day it would be possible for a pilot to go to his destination by strictly following the visual markings on the ground along a route of flight. However, on a cloudy day the pilot cannot see the ground and must fly blind through the use of instruments in the cockpit which follow the electronic beam from the VOR station. Otherwise the pilot would become hopelessly lost and crash.

Man can locate himself and find points (fixes) through stimulation of the senses of sight, sound and feel. Occasionally, smell can be used when the aroma is of a directional nature such as the case of a dog tracking a rabbit. Through instruments in the cockpit, the VOR station stimulates the "visual" bombing capabilities of the pilot.

Map Reading

Objective:

You will take the materials given and correctly complete the following tasks:

1. Plan a trip through at least 4 towns.
2. Compute the total distance.
3. Compute the time enroute for each leg.
4. Compute the total time enroute.
5. Compute the fuel required based on given information.

Materials:

1. One road map preferably of the local area.
2. One enroute planning log.
3. One route plan sheet.

Procedure:

1. Unfold map and locate your starting point.
2. Determine the town through which you wish to travel. You may end at the town from which you started--this is called a round robin.
3. Fill out enroute planning logs. (self explanatory)
4. Compute the totals from the log in the last columns.
5. Use the enroute planning log to complete your route plan sheet.
6. Give the route plan sheet to your instructor. He will record actual departure time.
7. If your trip exceeds 420 miles, complete two or more route plan sheets, terminating each route plan sheet at each refueling stop. Have an enroute planning log to backup each route plan sheet.

Student Activity #2

Model VOR Station

Objective:

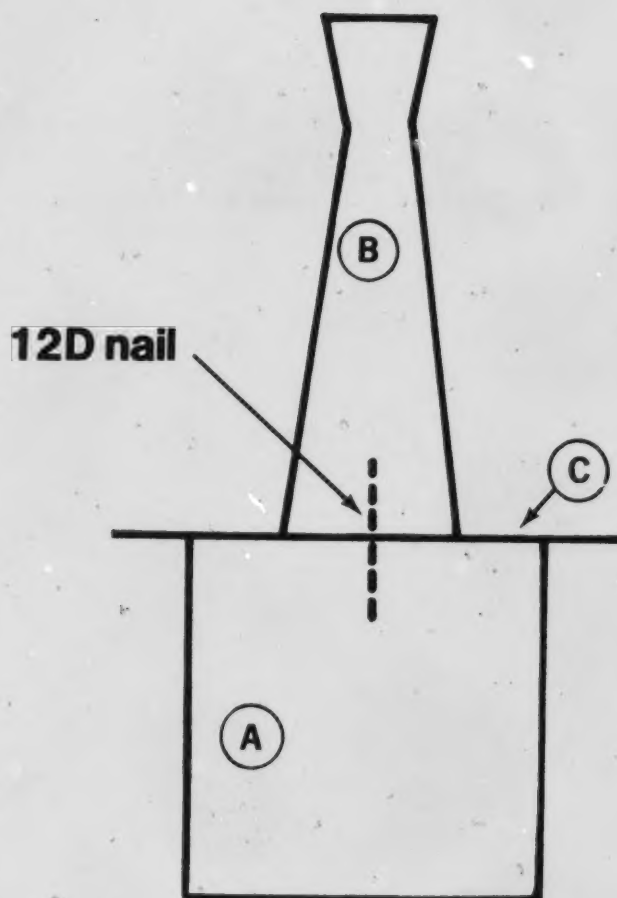
You will take the materials given and correctly construct a model VOR station.

Materials:

1. One 4" X 4" X 4" block or enough wood to form a 4" X 4" X 4" block—preferably pine.
2. One 6" X 6" piece of poster board.
3. One 12D nail.
4. One 2" X 2" X 6" block.
5. Black ink.
6. White paint.

Procedure:

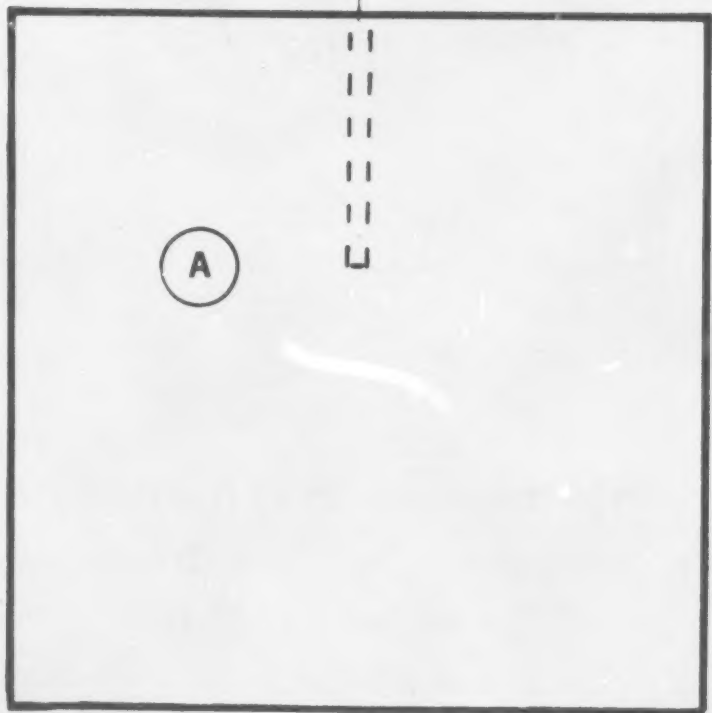
1. Construct a 4" X 4" X 4" block and drill according to plans.
2. Turn 2" X 2" X 6" block and drill according to plans.
3. Remove head from nail.
4. Draw a 6" circle on the poster board and cut out.
5. Mark the circle each 10° as shown in Demo #1 using the black ink. Label each 30°.
6. Paint all wood parts white.
7. Assemble the model as shown.
8. Hand model to your instructor for evaluation.
9. Retain model for use in the next unit.



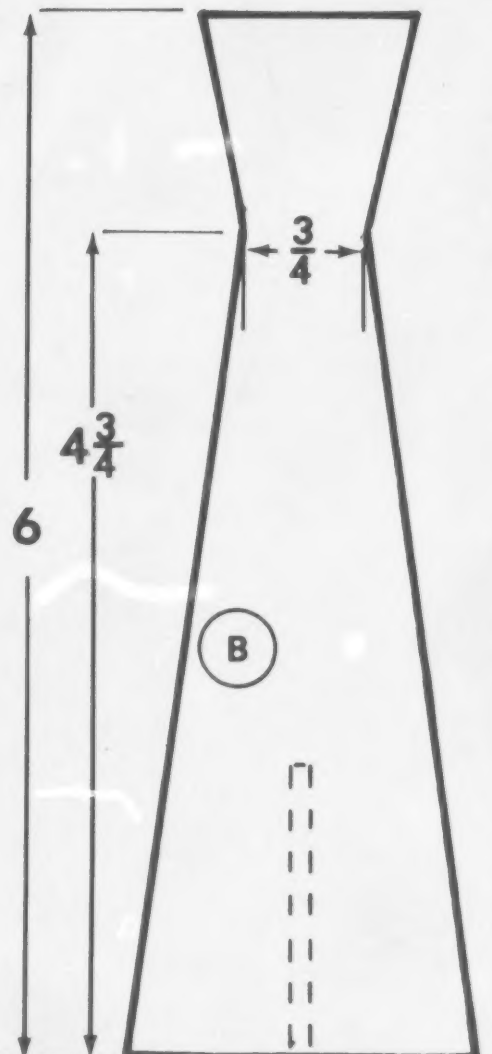
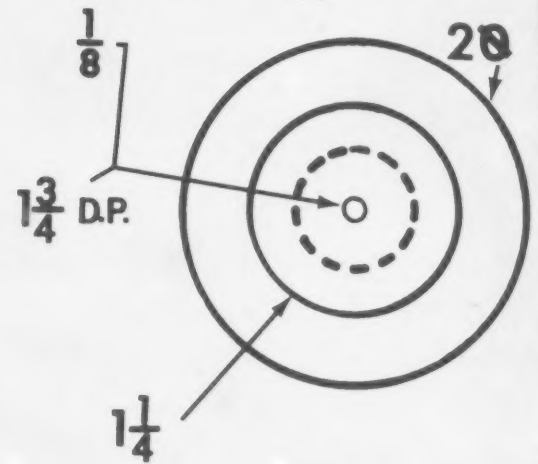
VOR STATION ASSEMBLY
Front view
(half scale)



4

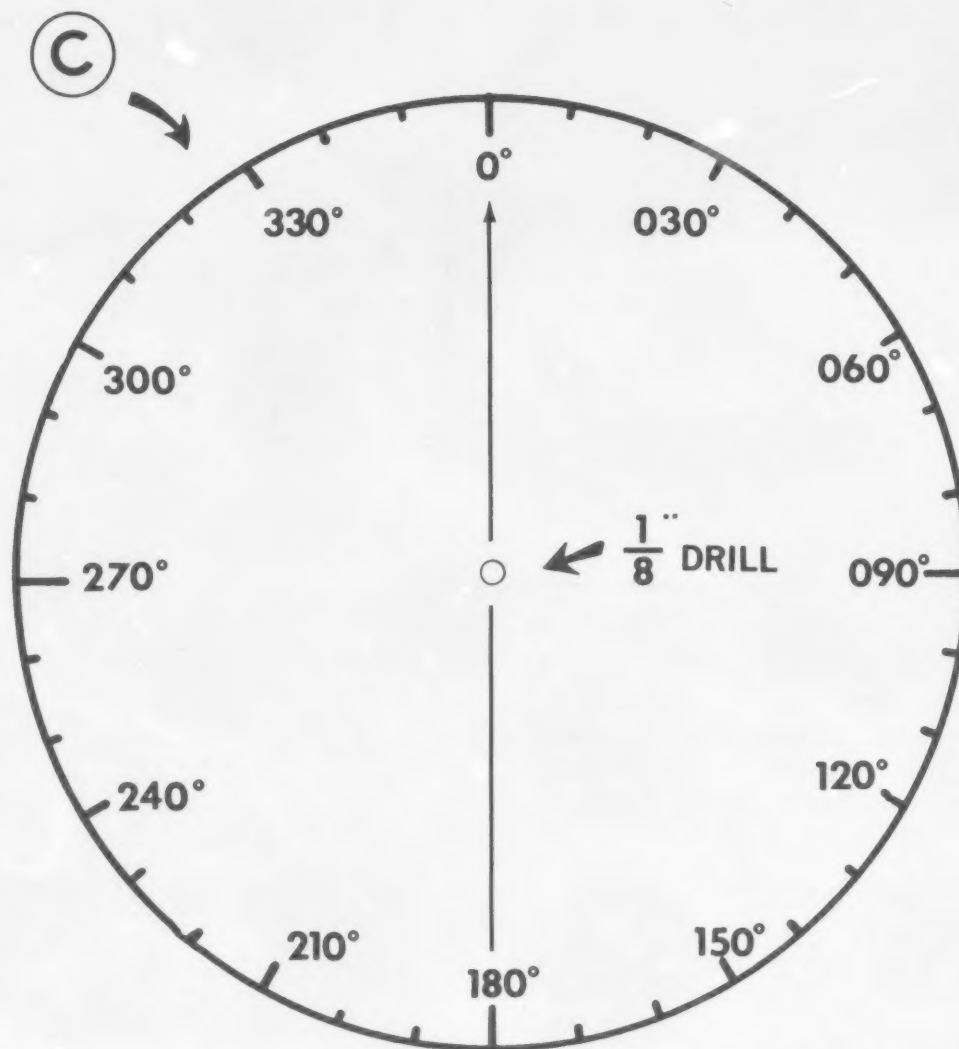


VOR Station Base



Antenna

VOR STATION DISC (poster board)



Note: VOR Station discs do not have bearings painted on them, but for instructional purposes they are drawn here. The 0-180 ARROW should be aligned with the TAPE ARROW on the classroom floor.

Student Activity #3

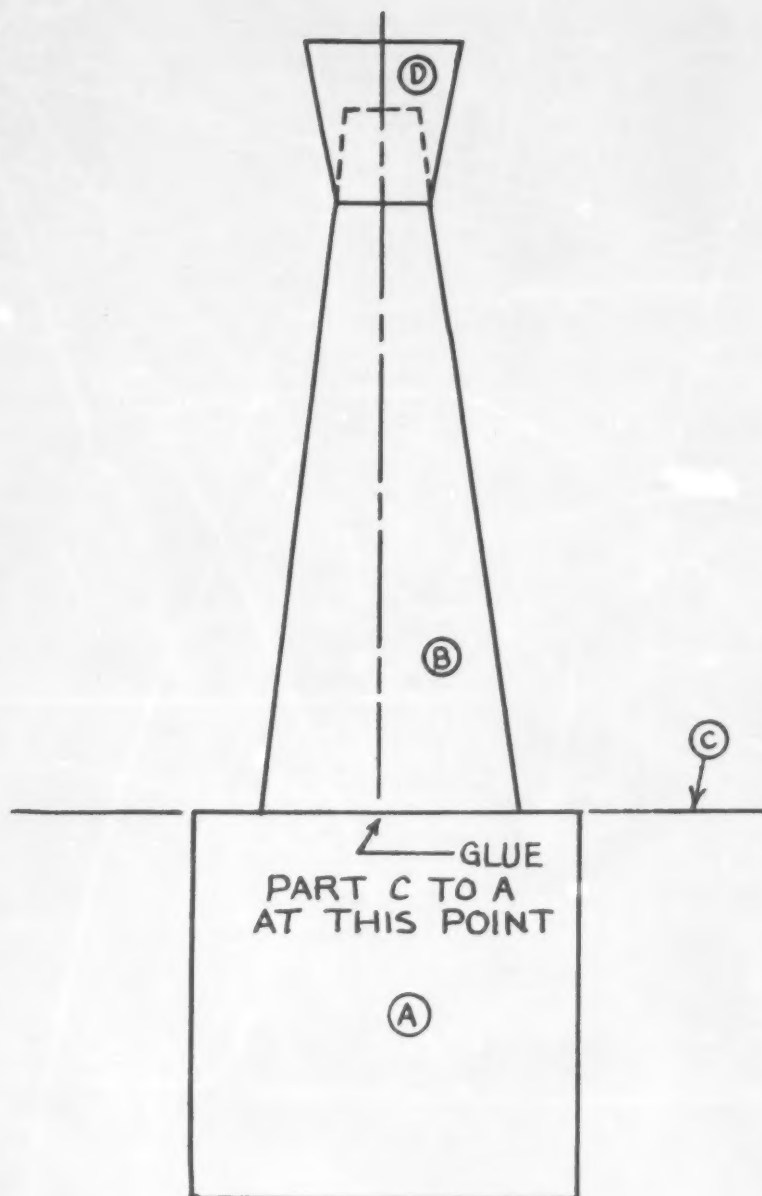
MODEL VOR STATION

Objective:

You will take the materials given and correctly construct a model VOR station.

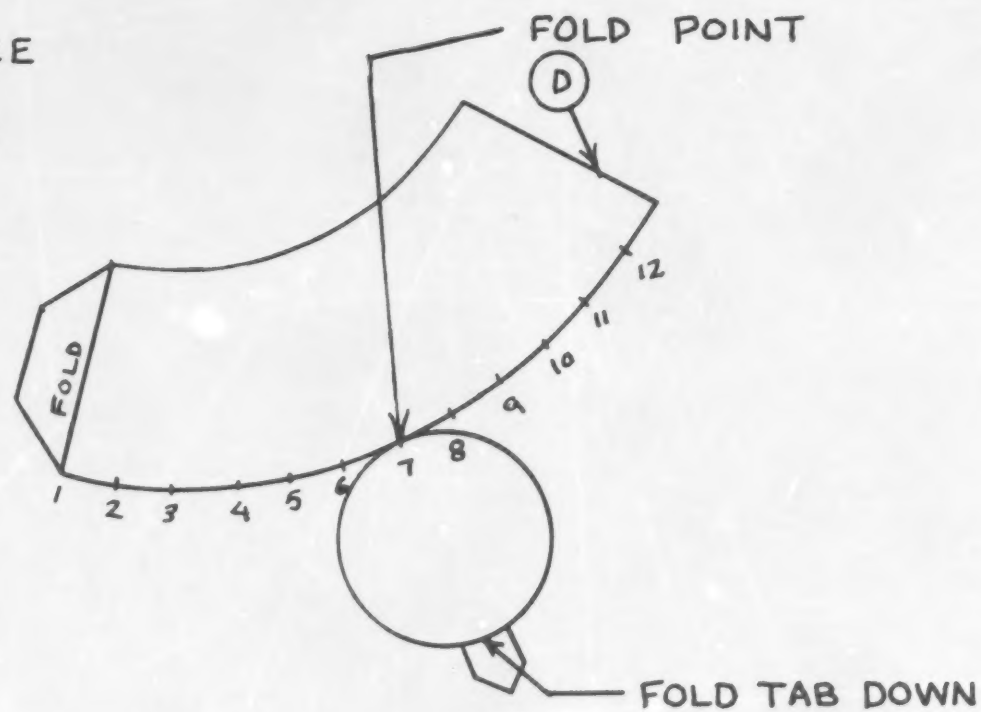
Materials:

1. Attached copy of parts layout.
2. At the discretion of your instructor, either trace the parts using carbon paper on poster board, construction paper or heavy drafting paper, or use the attached parts themselves and cut out the parts.
3. Apply rubber cement in the appropriate places and fold and glue as shown.
4. Assemble parts as shown in the alternate view assembly drawing.
5. Hand the model to your instructor.
6. Retain model for use in the next units.



ALTERNATIVE PAPER MODEL OF
VOR STATION- ASSEMBLY DRAWING.

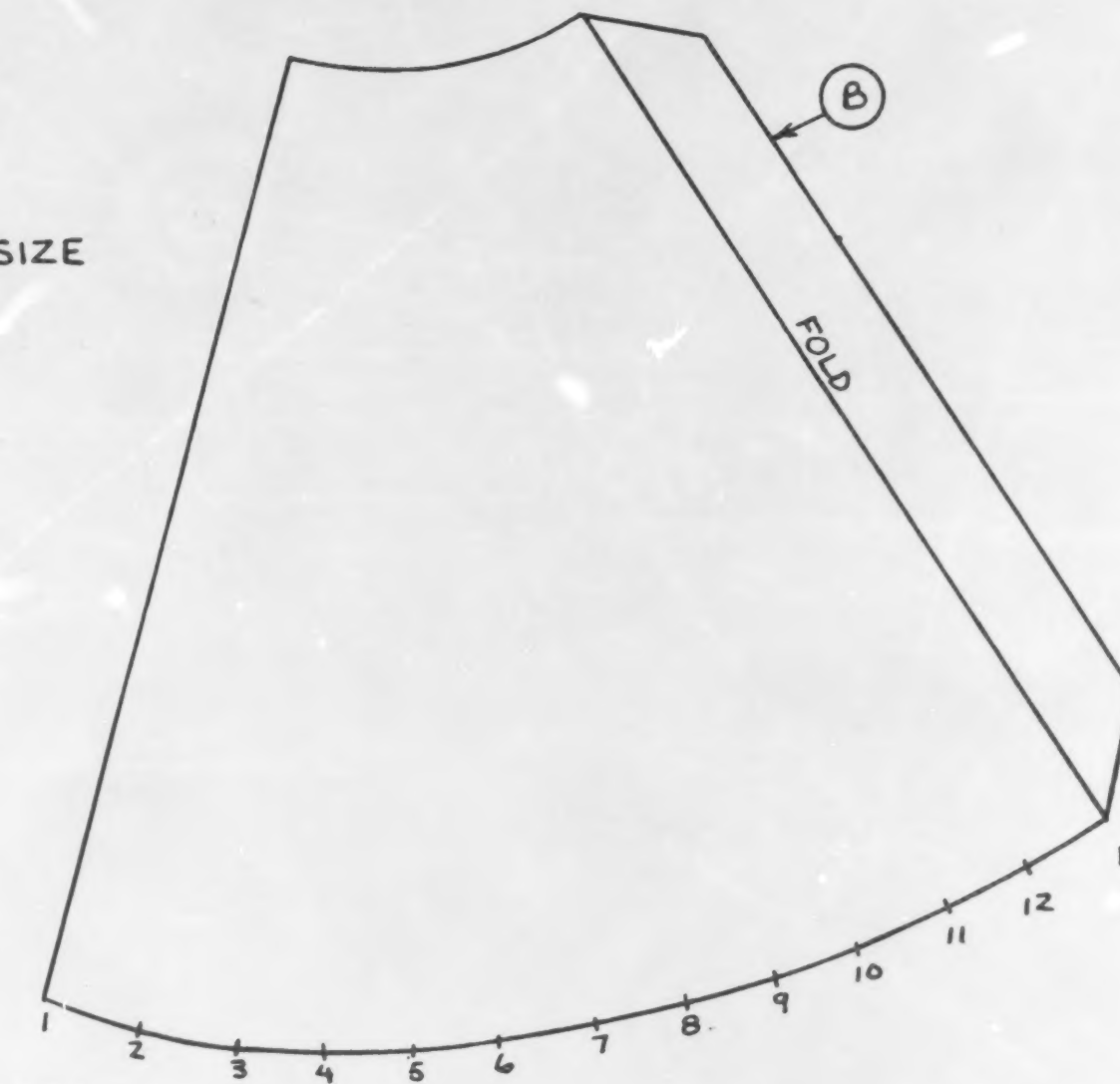
ACTUAL SIZE



262

263

ACTUAL SIZE



264

265



ALTERNATIVE VOR
STATION BASE.

Model Airport

Objective:

You will take the materials given and correctly construct a model airport.

Materials:

1. One 24" X 24" X 1/4" piece of plywood.
2. Green paint.
3. Gray and/or black paint.
4. Yellow paint.
5. White paint.
6. Blocks or cardboard for constructing buildings as you desire (This material is not necessary).

Procedure:

1. Decide on an airfield layout utilizing at least 3 runways. Add a helicopter landing area if desired. (Some suggested layouts attached)
2. Paint the plywood board green.
3. Layout the airfield on the plywood board. Use a scale 1" = 500'.
4. Paint on the runways and taxiways using either black or gray paint. Paint the helo-landing area black or gray.
5. Paint the proper numbers on the runway using white paint.
6. Paint on the centerline using either white or yellow paint.
7. Paint a hold short line on each taxiway using yellow paint.
8. Paint the helicopter landing area using white paint. Make the outer border 50' X 50' for the helo area. Use a scale 1"=25' for the helicopter landing area.
9. Locate an area on the airfield for a compass rose--make it at least 100' in diameter and mark off the cardinal headings. Use white paint for a center circle and outer circle and radiate the lines from the center using the yellow paint. Use a scale 1"=50' for the compass rose.

10. Add buildings, control tower, etc. as you like.
11. Give the completed airfield to your instructor for evaluation.
12. Retain the airfield for use during the next unit.
13. Add a wind-sock or tetrahedron to the field if you like.

COMPASS READING

Objective:

You will take the materials given and correctly determine the magnetic course of the road in front of the school.

Materials:

1. One magnetic compass.
2. One sheet of white paper.

Procedure:

1. Draw a square block 2" x 2" on the paper. This block represents the school.
2. Draw a road 1/2" wide in front of the school and parallel to it. Make the road 4" long and put break lines at each end.
3. Go outside and let the compass point to the north. Locate an arrow on the paper that points to the magnetic north.
4. Determine the magnetic course of the road. Put an arrow on the road pointing both directions and write the two magnetic courses down.

UNIT TEST

1. The place on the airfield where an airplane takes off and lands is called a:
 - a. Roadway
 - b. Taxiway
 - c. Airway
 - d. Runway
2. The closed end of the triangle painted on a helicopter landing pad points to the:
 - a. True North
 - b. Magnetic North
 - c. South
 - d. Top
3. The piece of equipment which supplies electrical power to an airplane while it is parked on the airfield is called a/an:
 - a. APU
 - b. Gas truck
 - c. Boarding ramp
 - d. Anemometer
4. The numbers on the end of the runway indicate the _____ landing direction.
 - a. True
 - b. Magnetic
 - c. Length of the
 - d. Distance in feet to the
5. The thing that the wind sock, wind tee and tetrahedron all have in common is that they indicate _____.
 - a. Wind speed
 - b. Wind direction
 - c. Landing speed
 - d. Landing direction
6. A civilian landing field with night landing facilities will have a rotating beacon flashing:
 - a. One red and one green flash
 - b. One green and two white flashes
 - c. One green and one white flash
 - d. One yellow and one green flash

7. When an aircraft is being refueled, smoking is not permitted within:
 - a. 50 feet
 - b. 100 feet
 - c. 500 feet
 - d. 1000 feet
8. Take-off and landing instructions are given to the pilot by the air controller located in the:
 - a. Restaurant
 - b. Flight Planning Area
 - c. Airport Manager's office
 - d. Control Tower
9. The thing that all VOR stations, TACAN stations and Low Frequency Homers have in common is that they are used for:
 - a. Music transmission
 - b. Emergency broadcasts
 - c. Air navigation
 - d. Aerial photography
10. The yellow line pointed across a taxiway over which an airplane may not cross on to the active runway unless cleared is called the:
 - a. Stop line
 - b. Taxi line
 - c. Hold short line
 - d. Exit line

ANSWERS TO TEST

1. d
2. b
3. a
4. b
5. b
6. c
7. a
8. d
9. c
10. c

MATERIALS

1. 1 magnetic compass
2. 1 chalkboard drawing compass
3. 24 sheets of plain white paper
4. 6 small drafting compasses
5. 6 straight edges
6. 1 roll masking tape
7. 7 road maps of your area
8. 24 enroute planning logs
9. 24 route plan sheets
10. 24 4" X 4" X 4" pine blocks
11. 24 12D nails
12. 24 2" X 2" X 6" pine blocks (Lathe to turn blocks on)
13. 24 6" X 6" poster board (white)
14. scissors
15. 1 bottle black ink
16. 1 pint white paint
17. 24 24" X 24" X 1/4" plywood
18. 1 quart green paint
19. 1 quart black or gray paint
20. 1 pint yellow paint
21. 24 protractors
22. 24 architects scales
23. construction paper
24. assorted paint brushes
25. 1 bottle of rubber cement

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

AIR TRANSPORTATION SYSTEM

Title of Unit:

SERVICES

DESCRIPTION OF UNIT

This unit will cover the services available and needed to "Keep em flying". It will survey all services in the air transportation system which includes all maintenance, law enforcement, navigational, control, flight guard and information. The materials in this unit are designed for 10 hours of instruction.

UNIT OBJECTIVE

After completion of this unit, the student will be able to explain the services required to provide safe flight from one point to another. He will be able to relate the services to the facilities and explain why such services are necessary.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. Name the agency responsible for setting up and administering the airways in the United States.
2. List the functions performed by a maintenance activity.
3. Describe an airway.
4. State the difference between V and J Airways.
5. State the two conditions of flight and list the reason between the two conditions.
6. Explain why an approach is necessary.

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7. Complete the flight plan form and enroute log adequately.
8. Explain the term flight guard.
9. List the sources of information available to the pilot.
10. List the different controllers available to the pilot.

OUTLINE OF CONTENT

A. Law Enforcement

The Federal Aviation Administration (FAA) is the responsible agency for setting up the air transportation system. They issue regulations which specify requirements for pilots, aircrew and other people involved in the system; set standards and publish regulations for licensing, maintaining and operating aircraft; define minimum weather conditions for various types of flight; define and enforce controlled, restricted and prohibited airspace; set standards for certification of schools and instructors; control and flight check the federal airways and approaches; and provide aircraft accident investigation when required. This agency has all the power of a law enforcement agency and can deny license or certification to any individual, company, or corporation which violates its rules and regulations.

B. Maintenance

They periodically check and make repairs on all aircraft as part of a regular preventative maintenance program.

1. Power plants shop--Covers all phases of engine work, including engine replacement.
2. Air frames shop--Covers all phases of repair work on the airframe and skin of the aircraft. Also covers the hydraulic systems.
3. Electronic shop--Sometimes called avionics--Covers all phases of radio and navigation equipment repair required on the aircraft. It also takes care of electrical problems including the replacement of landing lights, etc.
4. Egress systems shop--Handles all life support systems such as oxygen, oxygen masks, and parachutes.

C. Navigational Service

The service provided through electronic emission from a navigational facility or radar vector.

1. Airways--Airways are roadways in the sky through which air traffic flows. These airways are determined by the FAA and located through visual and/or electronic means.
 - (a) VOR airways--These airways are 8 miles wide and extend from 1200 ft AGL (actual ground level), and in some instances higher, up to but not including 18,000' MSL (mean sea level). They are designated by a V and are called Victor Airways. There are 28 charts which cover this airway system in the US and are often called FLIP charts. Their real name however, is US Government Flight Information Publications.

Enroute Low Altitude Charts--US Series L-1 through L-28. These charts are also accompanied by a Low Altitude Enroute Supplement Book which gives information about all airports in the US. Some examples of Victor airways would be V-1, V-198, V-198W, etc. These airways are predicated solely on VOR/VORTAC navigation facilities.

- (b) Jet route system--The jet route system are airways which exist from 18,000' MSL (mean sea level) through 45,000 MSL. They are designated by a J followed by a number. There are 4 charts which cover this airway system and they are also called FLIP charts accompanied by a High Altitude Enroute Supplement Book. These charts are U.S. Series H-1 through H-4 Enroute High Altitude Charts. Some examples of the Jet Route System Airways are J-1, J-4, J-11, etc. The jet routes are predicated on VOR, VOR-DME and VORTAC navigation facilities shown on high altitude charts.
 - (c) Above 45,000' MSL--Flight above 45,000' MSL is conducted on a point-to-point basis using the facilities shown on the High Altitude Charts.
 - (d) Overwater and international navigation--Flight outside the United States is governed by international law. The United States Coast Guard maintains LORAN stations (Long Range Air Navigation) which provides services to aircraft 800-1000 miles out and even further depending on weather conditions. Also, in this new age of technology, computers and satellites provide navigation fixes for overwater flights. Some aircraft still use a navigator and star shots are made with a bubble sextant. Other countries use an airway system similar to that in the United States and use VOR facilities.
2. Control Zone--This is a zone around an airport which covers the airspace from the ground up to but not including 14,500' MSL. It is normally circular with a radius of 5 statute miles from the center of the airport and has extensions when necessary to include the instrument approach and departure paths. Their purpose is to provide air traffic control service to arriving and departing aircraft. Because control zones are not consistent in their dimensions, they will be shown on the air navigation charts. (Transparency 1)
 3. Airport traffic area--The airspace around an airport which covers a circular area with a radius of 5 statute miles from the center of the airport. It extends from the ground up to but not including 3000' AGL. These areas are not shown on the air navigation charts. (Transparency 2)

4. Positive control, restricted areas and prohibited areas--These are special areas in which an aircraft may or may not operate unless special conditions are met. Restricted areas and prohibited areas are shown on all air navigation charts. Positive control areas are shown on Enroute High Altitude charts. An example of a prohibited area is the White House in Washington D.C. No aircraft may overfly the White House. Restricted areas exist usually because of some hazard to navigation such as an artillery firing range or a military jet climb corridor.

D. Control

The control of an aircraft in flight through agencies or service which promote the safe operation of the aircraft.

1. Conditions of flight--Means the visual conditions under which an aircraft operates and the rules governing them.
 - (a) VFR--Visual flight rules. The pilot maintains a lookout and provides clearance from other aircraft.
 - (1) Weather conditions--Usually 1000' and 3 miles visibility. (See attached table. Transparency 3)
 - (2) Cruising altitudes--The altitude at which an aircraft operates if flying under visual flight rules. Usually some altitude in thousands of feet plus 500. (See attached table. Transparency 4)
 - (b) IFR--Instrument flight rules. The pilot is flying blind and cannot see the ground. Air Traffic Control assigns a route of flight and altitude that will keep the aircraft clear of other aircraft.
 - (1) Weather conditions--Only two limitations apply in the case of IFR flight. They are (1) SIGMET and (2) Landing Minima. Sigmet are significant meteorological conditions which exist such that flight through them would be hazardous (i.e. tornados or severe thunderstorms). Landing Minima is the existing conditions at the destination airport. Normally instrument rated pilots can make an approach if the weather is 300' and 1 mile visibility. Some specially rated pilots can make an approach and landing utilizing GCA at 100' and 1/4 mile visibility.
 - (2) Cruising altitudes--The altitude at which an aircraft operates if flying under instrument flight rules. Usually, the altitude is in thousands of feet. (See attached table. Transparency 5).

2. Air route traffic control--(ARTC or ATC)--The agency responsible for assigning the clearance for an aircraft to proceed from one point to another. This control is divided up among several centers across the United States. Some of the centers are located at Washington DC; Atlanta, GA; Miami, FLA; New York, NY; and Los Angeles, CA. In the Center Area, radar sets monitor the airways with a feed in to these several centers where the flight of the aircraft is monitored. Once the aircraft departs the control zone following takeoff, the pilot contacts the center on an assigned frequency. As the flight progresses, the pilot is asked to change frequencies to talk to the next controller along the route. Today, some aircraft possess altitude reporting equipment which automatically gives the controller an altitude read-out of the aircraft on the radar screen.
 3. Approach control/Departure control--The controlling agency at an airport responsible for clearing an aircraft to make an instrument approach to or departure from the airport. Approved instrument approaches are published and called approach plates. The aircraft arriving on an airway locates itself over the initial approach fix. Usually this is the VOR station or a Low Frequency Homer. From there a prescribed pattern is flown so that the pilot arrives at some minimum altitude where he has visual contact with the runway environment. Departure is just the reverse of this procedure.
 4. Ground control--The controlling agency at busy airports who issues taxi instructions to aircraft while on the ground. A pilot usually receives his flight clearance instructions from ground control or through a discreet clearance delivery frequency prior to taxi. The pilot must copy and read back his flight clearance correctly before he is permitted to take-off on an instrument flight plan.
 5. Control tower--The controlling agency which issues take-off and landing instructions at an airport. It also issues traffic pattern information to VFR traffic. Even though approach control clears an aircraft for an approach, the aircraft cannot land until cleared by the control tower.
- E. Flight guard--The Federal Aviation Agency attempts to monitor the take-off and landing of all aircraft departing, leaving and within the United States. This guard is a safety feature in the event the aircraft should crash, or become lost. While on an instrument flight plan, an aircraft is always guarded, but Visual Flight is a different situation. The filing of a flight plan is not mandatory and VFR traffic can come and go as it pleases from small airports. If no flight plan is filed, there is no flight guard. In the interest of safety, one should always file a flight plan. When an aircraft is overdue, FAA can then alert search and rescue.

- F. Information--Information necessary for the pilot to conduct a safe flight. This covers a broad area and a good pilot is always checking the information available to him.
1. Weather--Prior to take-off each pilot should get a weather briefing. There is a facility maintained at the airport for such a briefing on a telephone where the pilot can call the nearest weather service facility for such a briefing. He should be informed as to enroute weather, weather at the destination airport and the forecast weather.
 - b. Enroute--Weather broadcasts are given over most VOR and other navigation facilities enroute. These broadcasts are given 15 minutes before the hour and 15 minutes after the hour.
 - c. Destination--The pilot should contact the local weather station after landing and debrief the aerographer if he encountered significant weather conditions different from his original briefing.
 2. Flight--Information pertaining to flight conditions.
 - a. Prior to take-off--The pilot should check the NOTAMS (notice to airmen). These notes relate to fields, navigation facilities and other planned disruption of the normal establishment of the flight environment. (An example of the NOTAM might be 1300-1950Z 28 December, Lake City VOR out of service due to maintenance.)
 - b. Enroute
 - (1) Airport advisory area (non-tower airports)--A Flight Service Station (FSS) is located at these airports to provide advisory information to arriving and departing aircraft. These advisories provide wind direction and velocity, favored or designated runway, altimeter setting, known traffic, NOTAMS, airport taxi routes, traffic patterns and instrument approach procedures.
 - (2) Automatic Terminal Information Service (ATIS)--At large airports, a recording with the current terminal information broadcasts continuously on a designated frequency. Pilots arriving may tune in the ATIS frequency and receive the information necessary for approach and landing such as ceiling, visibility, wind, altimeter setting, instrument approaches and active runway. This feature saves time and eliminates some confusion in and around the airport.
 - (3) Aeronautical Advisory Stations (Unicom)--A frequency assigned to an airport or heliport over which general information may be passed from flight service to general aviation pilots, between pilots or to other personnel.

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- (4) Company frequencies--All airlines maintain company frequencies so that the pilot may call the dispatchers. He can request such things as fuel, maintenance service, etc. prior to arrival and pass any other general information necessary.

TEACHER ACTIVITIES

- I. Provide student with module.
- II. Make transparencies.
- III. Discuss Unit and Specific Objectives.
- IV. Discuss Information Sheets and go through Outline of Content giving Demonstrations as you go.
- V. Discuss Student Activity Sheets.
- VI. Supervise student activities.
- VII. Give test.
- VIII. Screen and grade student activities. Retain the best ones for use in the next unit. (Retain at least 6 of each)

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STUDENT ACTIVITIES

- I. Read Objective Sheet.
- II. Study Information Sheet.
- III. Complete Activity Sheets.
- IV. Take test.

REFERENCES/RESOURCES

I. References:

1. Misenhimer, Ted G., Aeroscience, Los Angeles, Calif.; Aero Products Research, Inc., 1976.
2. Federal Aviation Regulations, Part I, Part 91.

II. Resources:

- A. Information Sheets
- B. Transparency Masters
- C. Activity Sheets
- D. Enroute Low Altitude Flight Planning Charts

Terms and Definitions:

Advisory Service--Advice and information provided by a facility to assist pilots in the safe conduct of flight and aircraft movement.

Air Navigation Facility (NAVAID)--Any facility used in, available for use in, or designed for use in aid of air navigation, including landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio direction-finding, or for radio or other electronic communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing or takeoff of aircraft.

Airport Advisory Area--The area within five statute miles of an uncontrolled airport on which is located a Flight Service Station so depicted on the appropriate Sectional Aeronautical Chart.

Airport Advisory Service--A service provided by a Flight Service Station to enhance the safety of terminal operations of airports where a station is operating but where there is no control tower.

Airport Information Desk (AID)--A local airport unmanned facility designed for pilot self-service briefing, flight planning and filing of flight plans.

Airport Traffic Control Service--Air traffic control service provided by an airport traffic control tower for aircraft on the movement area and in the vicinity of an airport.

Airport Traffic Control Tower (TOWER)--A facility providing airport traffic control services.

Airport Traffic Area--Unless otherwise specifically designated (FAR Part 93), that airspace which has a horizontal radius of five statute miles from the geographical center of the airport at which a control tower is operating, extending from the surface up to, but not including 3,000 feet above the surface.

Air Route Surveillance Radar--Long range radar which increases the capability of ATC for handling heavy enroute traffic. An ARSR site is usually located at some distance from the Air Route Traffic Control Center it serves. The range is approximately 200 miles.

Air Route Traffic Control Center (CENTER)--A facility established to provide air traffic control service to aircraft operation on an IFR flight plan within controlled airspace and principally during the enroute phase of flight.

Air Traffic--Aircraft operating in the air or on an airport surface, exclusive of loading ramps and parking areas.

Air Traffic Clearance--An authorization by air traffic control for the purpose of preventing collision between known traffic, for an aircraft to proceed under specified traffic conditions within controlled airspace.

Air Traffic Control Service--A service provided for the purpose of promoting the safe, orderly, and expeditious flow of air traffic, including airport, approach, and enroute air traffic control service.

Approach Control Service--Air traffic control service, provided by a terminal area traffic control facility, for arriving and departing IFR aircraft and, on occasion, VFR aircraft.

Automatic Terminal Information Service (ATIS)--The continuous broadcast of recorded noncontrol information in selected high activity terminal areas. Its purpose is to improve controller effectiveness and to relieve frequency congestion by automating the repetitive transmission of essential but routine information.

Cardinal Altitudes or Flight Levels--"Odd" or "even" thousand-foot altitudes or flight levels.

Ceiling--The height above the earth of the lowest layer of clouds or obscuring phenomena that is reported as "broken", "overcast", and not classified as "thin" or "partial".

Controlled Airport--An airport controlled by a control tower.

Controlled Airspace--Airspace designated as continental control area, control area, control zone, or transition area, within which some or all aircraft may be subject to air traffic control.

Continental control area--Airspace at and above 14,500 feet MSL of the 48 contiguous states, the District of Columbia, and Alaska south of LAT. 68°N, excluding the Alaska peninsula west of Long. 160°W; but does not include airspace less than 1,500 feet above the surface of the earth, and prohibited and restricted areas (except certain specified restricted areas).

Control area--Unless otherwise provided, airspace extending upward from 1200 feet above the surface or from 300 feet below the Minimum Enroute Altitude, whichever is higher, to the base of the Continental Control Zone.

Control zone--Controlled airspace which extends upward from the surface of the earth and terminates at the base of the Continental Control Area. Control Zones that do not underlie the Continental Control Area have no upper limit. A control zone may include one or more airports and is normally circular with a radius of 5 statute miles and does include extensions when necessary to include instrument approach and departure paths.

Course--The intended direction of flight in the horizontal plane.

Cruise--A word used instead of the word "maintain" in an ATC clearance to indicate to a pilot that climb to and descent from the assigned altitude may be made at his discretion, and is authorization for the pilot to proceed to and make an approach at the destination airport.

Cruising Altitude--A level determined by vertical measurement from mean sea level.

Departure Control--A function of approach control providing service for departing IFR aircraft and on occasion, VFR aircraft.

Discrete Frequency--A frequency assigned a particular function.

Distance Measuring Equipment (DME)--Equipment (airborne and ground) used to measure, in nautical miles, the distance of an aircraft from a navaid.

En Route Air Traffic Control Service--Air traffic control service provided aircraft on an IFR flight plan, generally by centers, when these aircraft are operating between departure and destination terminal areas.

Flight Plan--Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an air traffic control facility.

Flight Service Station (FSS)--A facility operated by the FAA to provide flight assistance service.

Flight Visibility--The average forward horizontal distance from the cockpit of an aircraft in flight at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.

FLIP--Flight Information Publication.

Ground Visibility--Prevailing horizontal visibility near the earth's surface as reported by the U.S. Weather Bureau or an accredited observer.

IFR Conditions--Weather conditions below the minimum prescribed for flight under VFR.

Jet Routes--A high altitude route system at 18,000 feet MSL to Flight Level 450 inclusive. Jet routes are predicated on high altitude navigational aids.

Minimum Enroute IFR Altitude (MEA)--The altitude in effect between radio fixes which assures acceptable navigational signal coverage and meets obstruction clearance requirements between those fixes.

Minimum Reception Altitude (MRA)--The lowest altitude required to receive adequate signals to determine specific VOR fixes.

Notice to Airmen--A notice identified either as a NOTAM or Airmen Advisory containing information concerning the establishment, condition, or change in any component of, or hazard in, the National Airspace System, the timely knowledge of which is essential to personnel concerned with flight operations.

NOTAM--A Notice to Airmen in message form requiring expeditious and wide dissemination by telecommunications means.

Airmen Advisory--A notice to Airmen normally only given local dissemination, during preflight or in-flight briefing or otherwise during contact with pilots.

Prohibited Area--Airspace of defined dimensions identified by an area on the surface of the earth within which flight is prohibited.

Radar Flight Following--The radar tracking of identified aircraft targets and the observation of the progress of such flights sufficiently to retain identity.

Radar Service--A term which encompasses one or more of the following services based on the use of radar which can be provided by a controller to a pilot of a radar identified aircraft.

Radar Separation--Radar spacing of aircraft in accordance with established minima.

Radar Navigation Guidance--Vectoring aircraft to provide course guidance.

Radar Monitoring--The radar flight following of aircraft, whose primary navigation is being performed by the pilot, to observe and note deviations from its authorized flight path airway, or route. This includes noting aircraft position relative to approach fixes and major obstructions.

Radial--A radial is a magnetic bearing extending from a VOR, VORTAC or TACAN.

Restricted Area--Airspace of defined dimensions identified by an area on the surface of the earth within which the flight of aircraft, while not wholly prohibited, is subject to restrictions.

Route--A defined path, consisting of one or more courses, which an aircraft traverses in a horizontal plane over the surface of the earth.

Separation--Spacing of aircraft to achieve their safe and orderly movement in flight and while landing and taking off.

Separation Minima--The minimum longitudinal, lateral, or vertical distances by which aircraft are spaced through the application of air traffic control procedures.

Track--The flight path of an aircraft over the surface of the earth.

Uncontrolled Airport--An airport which does not have a control tower.

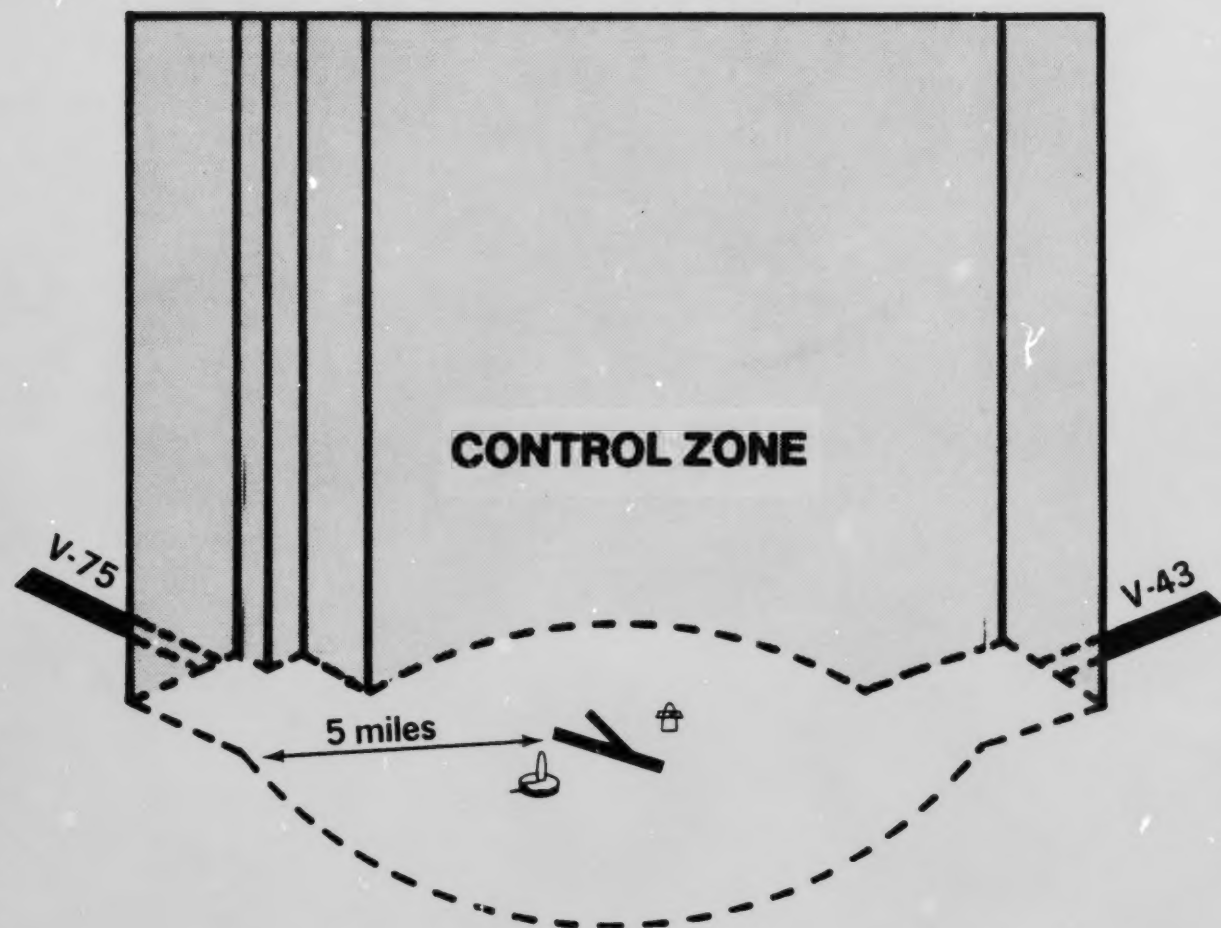
VFR Conditions--Basic weather conditions prescribed for flight under Visual Flight Rules when the pilot can see the ground.

Visibility, Prevailing--The horizontal distance at which targets of known distance are visible over at least half of the horizon. It is normally determined by an observer on or close to the ground viewing buildings or other similar objects during the day and ordinary city lights at night. Under low visibility conditions the observations are usually made at the control tower. Visibility is reported in miles and fraction of miles in the Aviation Weather Report. If a single value does not adequately describe the visibility, additional information is reported in the "Remarks" section of the report.

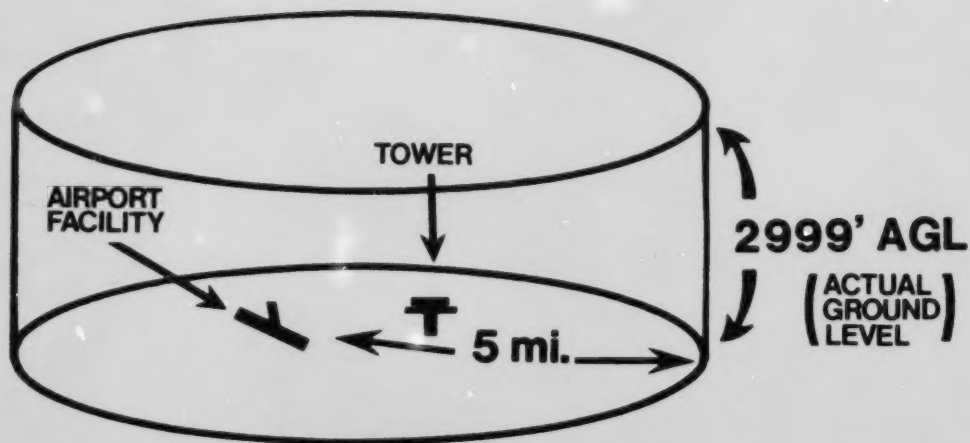
Warning Area--Airspace which may contain hazards to nonparticipating aircraft in international airspace.

Weather Advisory--In aviation weather forecast practice, an expression of anticipated hazardous weather conditions as they affect the operation of air traffic and as prepared by the Weather Bureau.

14,500 Continental Control Area



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Control Zone
AIRPORT TRAFFIC AREA

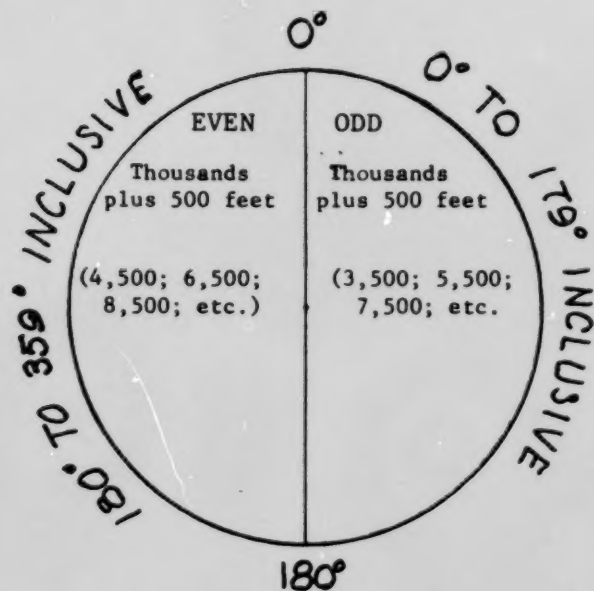
VISUAL FLIGHT RULES
VISIBILITY AND DISTANCE FROM CLOUD REQUIREMENTS

Altitude	Flight Visibility	Distance from clouds
1,200 feet or less above the surface (regardless of MSL altitude)-		
Within controlled airspace - -	3 statute miles	500 feet below. 1,000 feet above 2,000 feet horizontal.
Outside controlled airspace - -	1 statute mile	Clear of clouds.
More than 1,200 feet above the surface but less than 10,000 ft. MSL-		
Within controlled airspace - -	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
Outside controlled airspace - -	1 statute mile	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface and at or above 10,000 feet, MSL.	5 statute miles	1,000 feet below 1,000 feet above 1 mile horizontal

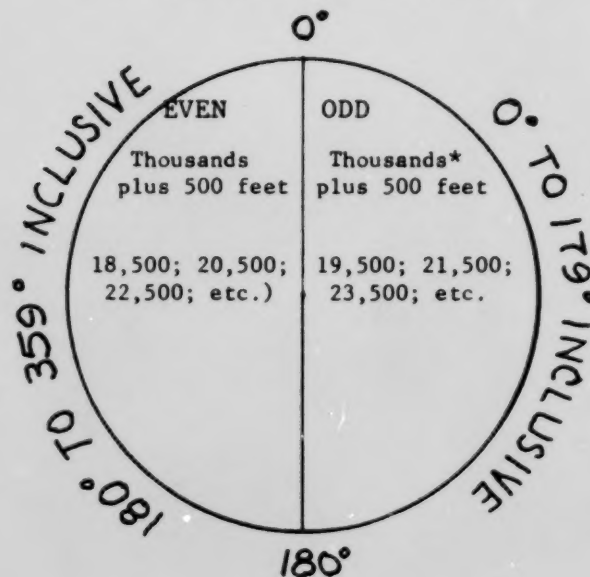
VISUAL FLIGHT RULES

ALTITUDES IN CONTROLLED AND UNCONTROLLED AIRSPACE

Below 18,000 Feet



Above 18,000 Feet MSL to
Flight Level 290 (inclusive)



ABOVE 29,000 Feet MSL

No VFR Flight is permitted in Area of Positive Control (APC). APC begins at 24,000' MSL except over the Northeastern USA, where it begins at 18,000 MSL.

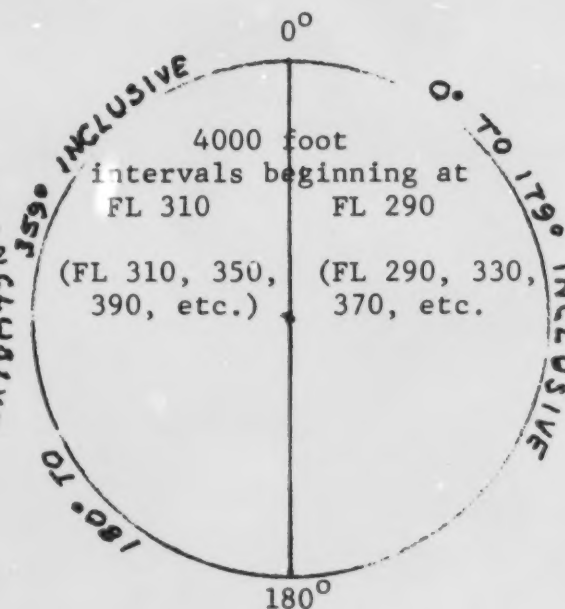
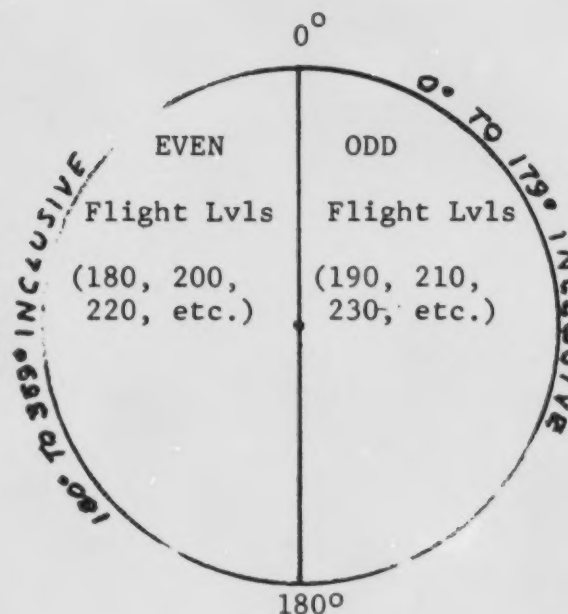
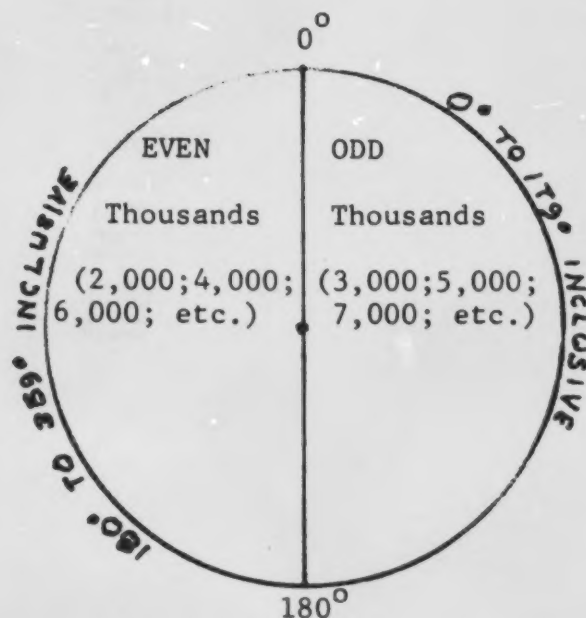
*Note: Altitudes up to and including 18,000 ft. MSL are expressed in thousands of feet. Altitudes above 18,000 ft. MSL are expressed as Flight Levels. 18,500 feet therefore will translate to Flight Level 185.

INSTRUMENT FLIGHT RULES ALTITUDES/FLIGHT LEVELS IN UNCONTROLLED AIR SPACE

Below 18,000 feet

At or above 18,000 feet MSL
but below Flight Level 290

At and above Flight Level
290



NOTE: In controlled airspace, Air Traffic Control attempts to stay very close to this altitude criteria. Pilots should use these rules when filing Instrument Flight Plans.

Student Activity #1

Airway Layout

Objective:

You will take the materials given and correctly complete the following tasks: (1) layout an airway in the classroom or shop area, (2) locate airfield along the airway, (3) position the navigation facilities along the airway, and (4) designate intersections.

Materials:

1. At least 6 of the airfields your class previously built.
2. Several of the VOR facilities your class previously built.
3. A yardstick.
4. 1/4" masking tape (several rolls).

Procedure:

1. Decide where you desire to place the airfields and locate them. (Note: They do not necessarily have to be on the floor--this is air transportation.)
2. Place one VOR facility model near the airfield.
3. Determine how you would like an airway link-up between the airfields. Your airway can go across lockers, desks, chairs, etc.; however it is suggested that small portable pieces of furniture be moved.
4. Using a scale 1" = 1 mile, lay tape on the floor to mark off the airways. They will be 8" wide.
5. Position a VOR NavAid about every 60-100 miles along the route.
6. If two airways cross and you have no more navaids, place a 3" equilateral triangle on the floor. That is an intersection.
7. Name your airfields and Navaids. Assign a frequency to each Navaid. Also assign call signs (three letters from the name if possible). Use frequencies 112.5 MHz through 117.9 MHz for your stations. Write the name, frequency and call letters on a piece of paper and lay beside the Navaid Facility.

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8. Turn the compass rose on each VOR station so that the North-South arrow is parallel to the tape arrow you put on the floor during the unit on Facilities.
9. Look at the compass rose and determine the magnetic course for each leg of the airway.
10. Tape off a control zone around each airport.

Student Activity #2

Airway Maps

Objective:

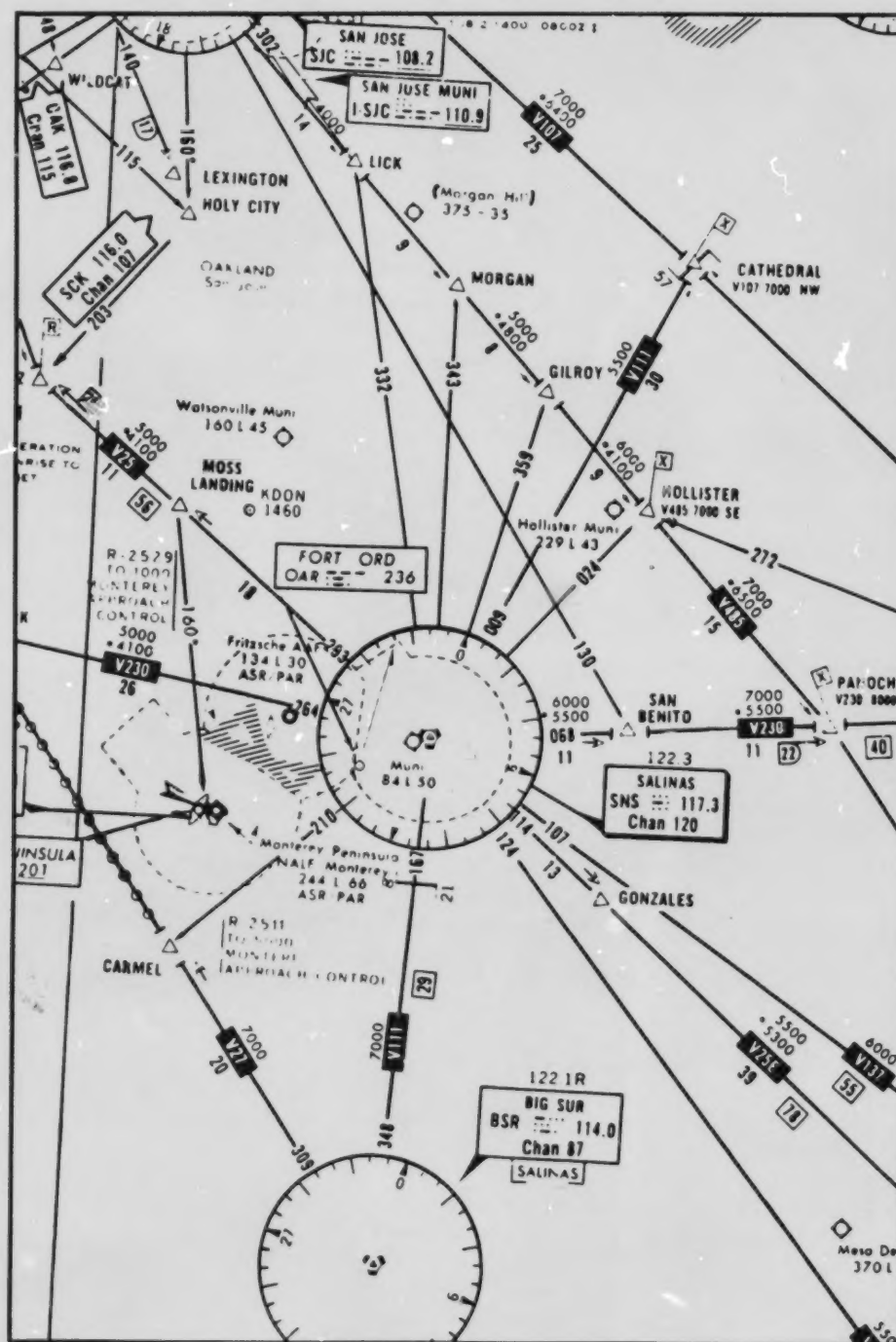
You will take the materials given and correctly draw a map of the airways in the classroom. This map will be used for flight planning in the next student activity.

Materials:

1. 1 sheet of paper.
2. Compass (drafting) or circle templates.
3. 1 protractor*
[*or drafting machine]
4. 1 straight edge*

Procedure:

1. Tape paper in position. Locate the north direction on the paper.
2. Draw a single line floor plan of the room.
3. Locate the points where you have your VOR stations set.
4. Draw a circle (convenient size) around each location.
5. Determine North and divide the circles up into 10 degree segments.
6. Draw in the course lines lightly.
7. Provide other information as shown in attached example. Channel numbers are TACAN, you may omit them.
8. Determine your minimum enroute altitude. Use a scale 8" = 500' or some other scale is more convenient. The floor is a Mean Sea Level.) (Your MEA must be 1000' above the highest object within a radius of 25 miles.)
9. Estimate the Minimum Reception Altitude.
10. Give your map to the instructor for evaluation and retain it for the next student activity.



Low altitude charts-
U.S. Series L-1 through L-28

Flight Planning

Objective:

You will take the materials given and correctly file a flight plan and complete a flight log.

Materials:

1. Map from Activity #2.
2. Flight plan sheet.
3. Flight log.

Procedure:

1. Determine a route of flight you desire to make using the map from Activity II.
2. Complete the flight log by correctly filling in the blanks. Use zero wind and estimate your ground speed as 120 knots. The distance given on aeronautical charts is in nautical miles. A knot is nautical miles per hour.
3. Complete the flight plan by correctly filling in the blanks. DVFR is a VFR flight plan requiring an ATC clearance. Do not use this block.
4. Submit flight plan and log to your instructor for evaluation.

DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION				Form Approved OMB No. 04-80072	
FLIGHT PLAN					
1. TYPE ☒ VFR ☐ IFR ☐ DVFR	2. AIRCRAFT IDENTIFICATION N1234	3. AIRCRAFT TYPE / SPECIAL EQUIPMENT CESSNA 172	4. TRUE AIRSPEED 120 KTS	5. DEPARTURE POINT MAPLETOWN	7. CRUISING ALTITUDE 5000
6. DEPARTURE TIME PROPOSED (Z) ACTUAL (Z)					
8. ROUTE OF FLIGHT MPT VAE MDS V7 NDD					
9. ESTIMATION (Name of Airport & City) NAVIDAD MUNI. ANYTOWN, TENN		10. EST. TIME ENROUTE HOURS MINUTES 0 37		11. REMARKS	
12. FUEL ON BOARD HOURS MINUTES 4 00		13. ALTERNATE AIRPORT(S) PONCA		14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE JOHN DOE MAPLETOWN MUNI	
15. NUMBER ABOARD 4		16. COLOR OF AIRCRAFT RED & WHITE			
CLOSE VFR FLIGHT PLAN WITH <u>MUD FLATS</u> FSS ON ARRIVAL					

FAA Form 7233-1 (5-72)

FAA flight plan form - front.

Note to Instructor:

These forms may be obtained from any airport operations office, through the U.S. Government Printing Office or reproduced locally for classroom instruction.

FLIGHT LOG							
DEPARTURE POINT	VOR IDENT	RADIAL	DISTANCE	TIME	SPEED		
	TO	FROM	LEG	POINT-TO-POINT	CUMULATIVE	TA	STS
MPT							
CHECK POINT	MPT	049	5	2.5		STA	
MAPLE TOWN	116.4	137	68	34		ATA	120
MUD FLATS	117.5	137	28	14			
ZIMBANE	117.1	103	40	20			120
	214	103	18	9			
	114.5	135	22	10			120
NAVIDAD	116.2	135	15	7.5			120
		145	7				
DESTINATION	NAVIDAD	145	7	3.5			
			TOTAL	73	36.5		
PREFLIGHT CHECK LIST						DATE	
EN ROUTE WEATHER WEATHER ADVISORIES							
DESTINATION WEATHER							
ALTERNATE WEATHER							
FORECASTS							
NOTAMS AIRSPACE RESTRICTIONS							

SECTIONAL Aeronautical Charts

Scale 1:500,000

-FAA flight plan form back.

UNIT III AIR TRANSPORTATION

UNIT TEST

1. The person responsible for changing a flat tire on an aircraft would be located in:
 - a. The control tower
 - b. The terminal building
 - c. The Aircraft Maintenance Department
 - d. The concession stand
2. Taxi clearance at a large airport will normally be given by:
 - a. The control tower
 - b. Approach control
 - c. Radar control
 - d. Ground control
3. An aircraft cannot take off or land at a controlled airport unless he is cleared by:
 - a. The control tower
 - b. Approach control
 - c. Radar control
 - d. Ground control
4. A VOR Airway is:
 - a. 5 miles wide
 - b. 11 miles wide
 - c. 25 miles wide
 - d. None of the above
5. The bottom of an airway starts at:
 - a. The ground
 - b. 500' above the ground
 - c. 1200' AGL or 300' below the MEA, whichever comes first
 - d. The continental control zone
6. The agency responsible for setting up and controlling the federal airway system is the:
 - a. Federal Flight Administration
 - b. Federal Aviation Administration
 - c. Federal Aeronautical Association
 - d. Federal Control Agency

7. A control zone in the United States starts at the ground and extends up the bottom of the:
 - a. Continental control area
 - b. Minimum enroute altitude
 - c. 10,000 foot corridor
 - d. Airways
8. An airport traffic area is 10 N.M. across and extends up to but does not include:
 - a. 3000' AGL
 - b. 3000' MSL
 - c. 1200' AGL
 - d. 1200' MSL
9. The two conditions of flight are:
 - a. DVFR and IFR
 - b. VFR and DVFR
 - c. VFR and IFR
 - d. Fast and slow
10. Flight above 45,000' MSL is conducted on:
 - a. V airways
 - b. J airways
 - c. Not permitted
 - d. Point to point basis

ANSWERS TO TEST

1. C
2. D
3. A
4. B
5. C
6. B
7. A
8. A
9. C
10. D

MATERIALS REQUIRED FOR UNIT

1. One yardstick
2. 10 rolls 1/4" masking tape
3. 24 sheets paper 11 X 17
4. 6 small drafting compasses
5. 6 protractors
6. 6 straight edges
7. 24 flight plans
8. 24 flight logs

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

AIR TRANSPORTATION SYSTEM

Title of Unit:

VEHICLES

DESCRIPTION OF UNIT

This unit will cover all vehicles used to transport goods and people through the medium of air. It will acquaint you with the theory of how these vehicles operate, their description and uses. The materials in this unit are designed for 15 hours of construction.

UNIT OBJECTIVE

After the completion of this unit, the student will be able to describe the many types of air vehicles in use. He will be able to relate these vehicles to the several tasks which they are capable of performing and to some degree, explain how and why they operate.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Distinguish the difference between heavier-than-air and lighter-than-air craft.
2. Identify the different types of fixed wing aircraft.
3. Identify the different types of rotary wing aircraft.
4. Identify the components of heavier-than-air fixed wing aircraft.
5. Name the control surfaces of a fixed wing heavier-than-air craft.
6. Name the four forces that act on an aircraft in flight.

OUTLINE OF CONTENT

- I. Types of Aircraft--Any craft that moves in and navigates through the medium of air.
 - A. Lighter-than-air craft--Any craft whose weight is less than the air it displaces, therefore it rises.
 1. Balloon--A container which holds a gas, usually hot air. It is attached to a gondola and can only drift with the wind. The pilot can control altitude somewhat by either dumping weight or dumping gas.
 2. Airship--An engine driven lighter-than-air craft that can be steered.
 - a. Dirigible--If the airship is of a rigid construction is usually referred to as a dirigible. An inner framework is made of rigid members and then covered with an envelope. The envelope is filled with helium. Earlier, the envelope was filled with hydrogen which resulted in some tragic accidents.
 - b. Blimp--The bag of air airship which contains few or no rigid members is usually referred to as a blimp. Inflation of the bag itself provides the rigidity required. The blimp is also filled with helium gas. It has an attached gondola and engines and is powered in flight and steered.
 - B. Heavier-than-air craft--Any craft which does not displace its weight in the air and must rely on a mechanical device to produce lift. (Transparency #2)
 1. Fixed wing--Any craft which has one or more wings of the proper aerodynamic shape attached parallel to the lateral axis and perpendicular to the longitudinal axis of the craft. The wing does not move and lift is produced by air flowing over it.
 - a. Single engine--An aircraft with only one engine.
 - (1) Monoplane--An aircraft with only one wing.
 - (2) Bi-plane--An aircraft with two wings. In the past there have been three wings (and more) called tri-plane, etc.
 - b. Multi-engine--A heavier than air craft with more than one engine. Usually the engines are in even numbers but three engine planes have seen service. To date, the maximum number of engines on a line model was 8 (Howard Hughes plywood "Blue Goose"). Multi-engine aircraft can also have more than one wing.

- c. Glider/ Sailplane--A heavier-than-air craft which has no engine. It is either towed aloft by another aircraft or launched by a catapult. For sustained flight, sailplanes rely on thermals for lift.
2. Rotary wing--Any heavier-than-air craft which has a wing attached which rotates parallel to the lateral axis of the craft. The rotary motion of the wing may be driven either by the engine or by air flowing through it. If the rotor is driven by the engine it is called a helicopter. If the rotor is driven by air flowing through it, the craft is called a gyroplane or autogyro.
- a. Single rotor--An aircraft that is equipped with one large rotary wing is called a single rotor. All such single rotor craft must have a small rotor attached, usually at the tail, which rotates in a plane perpendicular to the plane of rotation of the main rotor and parallel to the longitudinal axis. This rotor is referred to the "auxiliary" or "anti-torque" rotor and is used for direction.
 - (1) Rigid rotor--The rotor is rigidly attached to the engine shaft and the blades remain outstretched whether the wing is rotating or not.
 - (2) Articulating rotor--The rotor is attached to the engine shaft through a series of bearings. When the rotor is turning, centrifugal force keeps the blades outstretched. They are free to lead and lag within limits and flap up or down. This helps to compensate for the lift differential caused by forward flight. When the blades are not turning they are kept outstretched by droop stops.
 - b. Multi-rotor--Helicopters equipped with two large rotors. These rotors are attached to each end of the helicopter, are intermeshed and rotate in opposite directions. Since their respective torques cancel each other, there is no need for an anti-torque rotor. This arrangement provides for a much larger loading area due to the shift in the center-of-gravity.
3. Rockets--Rockets are heavier-than-air craft which have no wings. They have only fins for directional control. The engines or a rocket are so powerful and provide so much thrust that the fuselage itself becomes a flying mechanism.

II. Components of a Fixed Wing Aircraft

- A. Fuselage--The part of an aircraft which holds the pay load section, cockpit and has the wings, rudder and elevator attached. In a tandem seat fixed wing aircraft, the pilot sits in the left seat. (Transparency #3)
- B. Empennage--This is the tail section of a fixed wing heavier-than-air craft and includes the vertical stabilizer, horizontal stabilizer, rudder and elevator.
- C. Wing--The member attached to the fuselage which produces lift and carries the weight of the aircraft. It may be mounted on top, beneath, or through the fuselage. Housed in the wings are flaps, slats and ailerons.
 - 1. Ailerons--Are two moveable surfaces on the back side of each end of the wing. They are attached to the yoke (control wheel) or stick and move up or down opposite to each other. They cause the airplane to roll about the longitudinal axis and provide for angle of bank for turning, rolling, etc.
 - 2. Flaps--Are moveable surfaces on the rear of the wing. They are lowered prior to landing to provide a more rapid descent, a steeper angle of descent and a slower airspeed. They change the shape of the wing.
 - 3. Slats--Are moveable surfaces on the front of the wing. These are also used prior to landing and takeoff. They change the shape of the wing and do basically the same thing as flaps.
 - 4. Special devices--Some aircraft have slots, boundary layer control and spoilers incorporated in the wing. These devices provide for slower airspeeds, steeper climb angles and more rapid rate of turn, roll or descent. Each type of aircraft is unique in what and how many of these devices are used. Mostly it depends on the mission of the aircraft. At one time, a military jet (F4U Crusader) had a wing that tilted up for takeoff. Today the new jets have swing wings which go from straight wing for takeoff to swept wing for cruise.
- D. Landing gear--In England this is called the undercarriage. It is the wheels or skids on which an aircraft lands. They can be retractable or fixed. They can be wheels, skids, skis or pontoons. Some aircraft have a combination of two or more devices for landing. If the airplane can land on both land and water, it is called an amphibian.

III. Components of a Rotary Wing Aircraft

- A. Fuselage--The same as that of a fixed wing aircraft. It holds the payload section, cockpit and has the rotors and landing gear attached. In a tandem seat rotary wing aircraft, the pilot sits in the right seat.
- B. Main rotor--The primary rotor which delivers lift to the fuselage and carries the weight of the aircraft.
- C. Anti-torque rotor or Auxiliary rotor--Because of the great amount of torque (twisting movement) generated by the main rotor on a single rotor helicopter, the rotor has a tendency to stop and let the fuselage rotate. In order to overcome this force it is necessary to use an anti-torque rotor. The pitch control of this rotor is attached to the rudder pedals. And as far as the pilot is concerned, it acts just the same as a rudder.
- D. Landing gear--Same types and functions as for fixed wing aircraft.

IV. Forces Acting on an Aircraft in Flight

An airplane flies when all forces are balanced. It maintains a constant altitude and airspeed. (Demo #1) (Transparency #5)
Those forces are:

- A. Thrust--The force which pulls or drives an aircraft forward. This force can be provided by the engine (usually) or gravity acting on the aircraft as used by a sailplane.
- B. Weight--The force of the earth attracting the aircraft. If there was no lift, it would fall just as a rock does.
- C. Lift--Generated by the flow of air over the wings. The shape of the wings is designed to take advantage of Bernoulli's principle. (Demo #2) That principle states "the movement of a fluid over a surface causes the reduction of pressure against the surface if the speed of the fluid is increased. (Transparency #6)
- D. Drag--The force holding back an aircraft. This is caused by the resistance of the air and the weight of the aircraft.

V. Control Axis of a Fixed Wing Aircraft

An aircraft must be controlled about 3 axes in flight. Those axes are:

- A. Pitch--The movement of the aircraft about the lateral axis. This axis goes through the wings and the nose pitches up and down. Its movement is controlled by the elevator. The elevator is a moveable surface attached to the rear of the horizontal stabilizer and works up and down as the stick or yoke is moved forward and backward. (Transparency #7)

- B. Roll--The movement of the aircraft about the horizontal axis. This axis goes from rear to front of the aircraft and out through the nose or prop if it is a single engine aircraft. The aircraft rolls about this axis. Its movement is controlled by the aileron. The ailerons are attached to the outer rear edge of the wings and cause the aircraft to roll left and right as the stick is pushed left and right or the yoke is turned left and right. (Transparency #8)
- C. Yaw--The movement of the aircraft about the vertical axis. This axis goes up and down through the center of the aircraft and is perpendicular to the lateral and horizontal axis. The aircraft yaws or turns about this axis. Its movement is controlled by the rudder. The rudder is attached to the rear of the vertical stabilizer and causes the aircraft to turn left and right as the rudder pedals are pushed left and right. (Transparencies 9 & 10)

VI. Control of a Rotary Wing Aircraft

The forces acting on a rotary wing aircraft are the same as a fixed wing. The controls are called:

- A. Cyclic--Attached to the stick which causes the main rotor to tilt left, right, forward and back. This action combines the forces of the ailerons and elevator in a fixed wing airplane.
- B. Collective--A stick beside the pilot which moves up and down and some have a twist handle on the end just like a motorcycle throttle. This lever is attached to the main rotor and increases the pitch angle of the main rotor blades. As the collective comes up, the blade angles increase taking a larger bite of air. Of course, this requires more engine power. The pilot twists the throttle on the end to keep the rotor RPM up to speed.
- C. Rudder--The rudder pedals are attached to the anti-torque rotor. This rotor is a pusher propeller and provides a compensating effect against the torque generated by the main rotor. It gives the same effect as the rudder in a fixed wing aircraft.
- D. Translational lift--While this is not a control, it is a very significant effect in the flight of a helicopter. For a helicopter to hover, the weight of the machine is supported by the engine alone. Once the helicopter transitions into forward flight, the air mass starts to move across the rotary wing. This movement of air produces lift in just the same manner as it does moving across a fixed wing. This lift is called translational lift and results in a very significant reduction of power. It can be used to increase the payload of a helicopter but a rolling take-off and rolling landing must be made.

VII. Major Uses of Aircraft

A. Lighter than air

1. Balloon

- a. Sport
- b. Observation
- c. Barrage--Small captive balloons which support wires or cables as a protection against air attack.

2. Blimps or Dirigibles

- a. Sport
- b. Observation
- c. Personnel and cargo transport
- d. Anti-submarine patrol

(NOTE: Present day usage of balloons and blimps are for sport and observation and advertisement. Most other uses have been phased out.)

B. Heavier-than-air

1. Fixed wing

- a. Cargo carriers
- b. Personnel carriers
- c. Sport
- d. Observation and/or photo-reconnaissance and mapping
- e. Search and rescue
- f. Military
 - (1) Fighters
 - (2) Bombers
 - (3) All other uses for which the civilian market uses them.
 - (4) Patrol
- g. Agriculture

VIII. Jobs in Aviation

Jobs in aviation can be categorized into 3 areas. Those areas are:

A. Operational or flight personnel

1. Pilot
 - a. Chief
 - b. Test
 - c. Airline
 - d. Military
 - e. Co-pilots
2. Navigator
3. Steward/Stewardesses
4. Military
 - a. Bombardier
 - b. Radar-operators
 - c. Ordnance men
 - d. Anti-submarine warfare specialist
5. FAA flight check specialists

B. Flight service personnel

1. Controllers
 - a. Tower
 - b. Approach/departure
 - c. Airway
2. Scheduling personnel (traffic agent)
3. Aerographers (weather forecasters)
4. Management
5. Security officers

6. Concession owners and employees
 7. Firefighters
 8. Airport maintenance people
 9. Fixed base operators
- C. Manufacturing, test and development, and maintenance
1. Aeronautical engineer
 2. Research mechanic
 3. Stress analyst
 4. Aerodynamist
 5. Air craft equipment and accessories assembler
 6. Propeller lay-out worker
 7. Rib builder
 8. Rocket engine tester
 9. Sub assembly inspector
 10. Plumbing systems tester
 11. Skin fitter
 12. Subassembly assembler
 13. Pressure sealer and tester
 14. Cable stretcher and tester
 15. Avionics technician
 16. Airplane electrician
 17. Wind tunnel mechanic
 18. Food test mechanic
 19. Airframe and powerplant mechanic
 20. Instrument repair technicians

TEACHER ACTIVITIES

- I. Provide student with module.
- II. Make transparencies.
- III. Discuss Unit and Specific Objectives.
- IV. Discuss Information Sheets and go through Outline of Material giving Demonstrations as you go.
- V. Discuss Student Activity sheets.
- VI. Supervise student activities.
- VII. Give test.
- VIII. Screen and grade activities.

STUDENT ACTIVITIES

- I. Read Objective Sheet.
- I
- II. Study Information Sheet.
- II. Complete Activity Sheets.
- IV. Take Test.

REFERENCES/RESOURCES

I. References:

- 1) Elementary School Aerospace Activities, "National Aeronautics and Space Administration", Washington D.C. 1977. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 Stock No. 033-000-00693-4
- 2) Air Age Education Aviation Career Awareness Program Kit, Edwin I. Petrie, Ohio State Univ. Available from Air Age Education Department, Cessna Aircraft Company, Wichita, Kansas 67201. "This is a group of units for elementary schools to provide an awareness of General Aviation and the careers it offers."

(NOTE: Closely related to the "World of Manufacturing" and ideally suited to middle schools.

- 3) Misenheimer, Ted G., Aeroscience, Aero Product Research, Inc. Los Angeles, CA 3rd ed. 1976.
Address: Aviation Education Department
Aero Products Research, Inc.
11201 Hindry Ave.
Los Angeles, CA 90045
- 4) Ahnstrom, D.N., The Complete Book of Jets and Rockets, World Publishing Co., Cleveland and New York, 1957.
- 5) Ahnstrom, D.N., The Complete Book of Helicopters, World Publishing Co., Cleveland and New York,
- 6) NASA, "Hesser, Edmond T.", Project Director, The World of Tomorrow, Aerospace Activities for 8 to 10 year olds, Govt. Printing Office, Washington D.C. 1978.
For sale by: Superintendent of Documents
U.S. Gov't. Printing Office
Washington, D.C. 20402
Stock No. 033-000-00745-1
- 7) Air Transportation, Dorthy Nelson, ed., Learning Management, Inc., Guilford, Conn. 1976.
- 8) Demonstration Aids for Aviation Education, National Aviation Education Workshop, Department of Transportation, Washington D. C. July 1972. Order Cat. No. GA-20-30 from Dept. of Trans., Federal Aviation Admin., Washington, D. C. 20591.
- 9) Gossage, H. and J. Manden, The Great International Paper Airplane Book, Simon and Schuster, New York, 1967.

II. Resources:

- A. Information Sheet
- B. Transparency Masters
- C. Activity Sheets
- D. Demonstrations

Airplane--Means an engine-driven fixed wing aircraft heavier than air, that is supported in flight by the dynamic reaction of air against its wings.

Airport--Means an area of land or water that is used or intended to be used for the landing and takeoff of aircraft, and includes its buildings and facilities, if any.

Air Traffic Control--Means a service operated by appropriate authority to promote the safe, orderly and expeditious flow of air traffic.

Auxiliary Rotor--Means a rotor that serves either to counteract the affect of the main rotor torque on a rotocraft or to maneuver the rotorcraft about one or more of its three principal axes.

Flight Plan--Means specified information relating to the intended flight of an aircraft that is filed orally or in writing with Air Traffic Control.

Flight Visibility--Means the average forward horizontal distance from the cockpit of an aircraft in flight, at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.

Glider--Means a heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces and whose free flight does not depend principally on an engine.

Ground Visibility--Means prevailing horizontal visibility near the earth's surface as reported by the United States Weather Bureau or an accredited observer.

Helicopter--A craft which has a motor driven rotating wing that also provides horizontal motion.

Maintenance--Means inspection, overhaul, repair, preservation, and the replacement of parts, but excludes preventive maintenance.

Navigable Airspace--Means airspace at and above the minimum flight altitudes prescribed by or under Federal Aviation Regulations Part I, including airspace needed for takeoff and landing.

Night--Means the time between the end of evening civil twilight and the beginning of morning civil twilight as published in the American Air Almanac, converted to local time.

Pitch Setting--Means the propeller blade setting as determined by the blade angle measured in a manner, and at a radius, specified by the instruction manual for the propeller.

Propeller--Means a device for propelling an aircraft that has blades on an engine driven shaft and, when rotated, produces by its action on the air, a thrust approximately perpendicular to its plane of rotation.

AT 4.14

Reporting Point--Means a geographical location in relation to which the position of an aircraft is reported, usually over a VOR station.

Rocket--Means an aircraft propelled by ejected expanding gases generated in the engine from self-contained propellants and not dependent on the intake of outside substances.

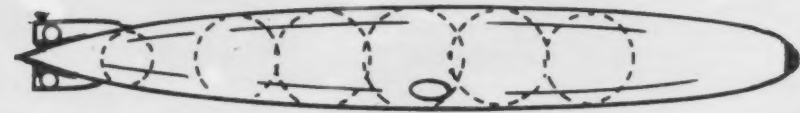
Rotorcraft--Means a heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors.

LIGHTER-THAN-AIR CRAFT

Airships



↓
**Balloon
with basket**



↩ **Dirigible (rigid)**



↩ **Blimp (non-rigid)**

325

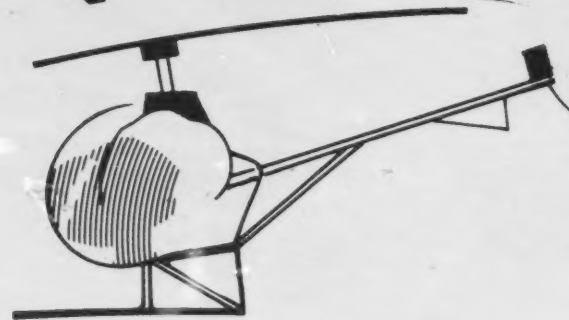
326

HEAVIER-THAN-AIR CRAFT

Glider



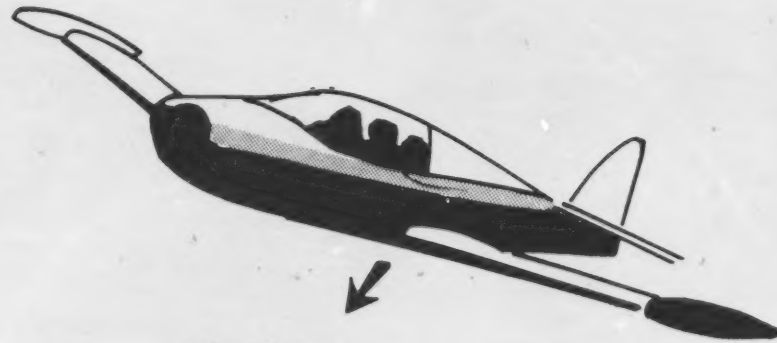
Rotorcraft



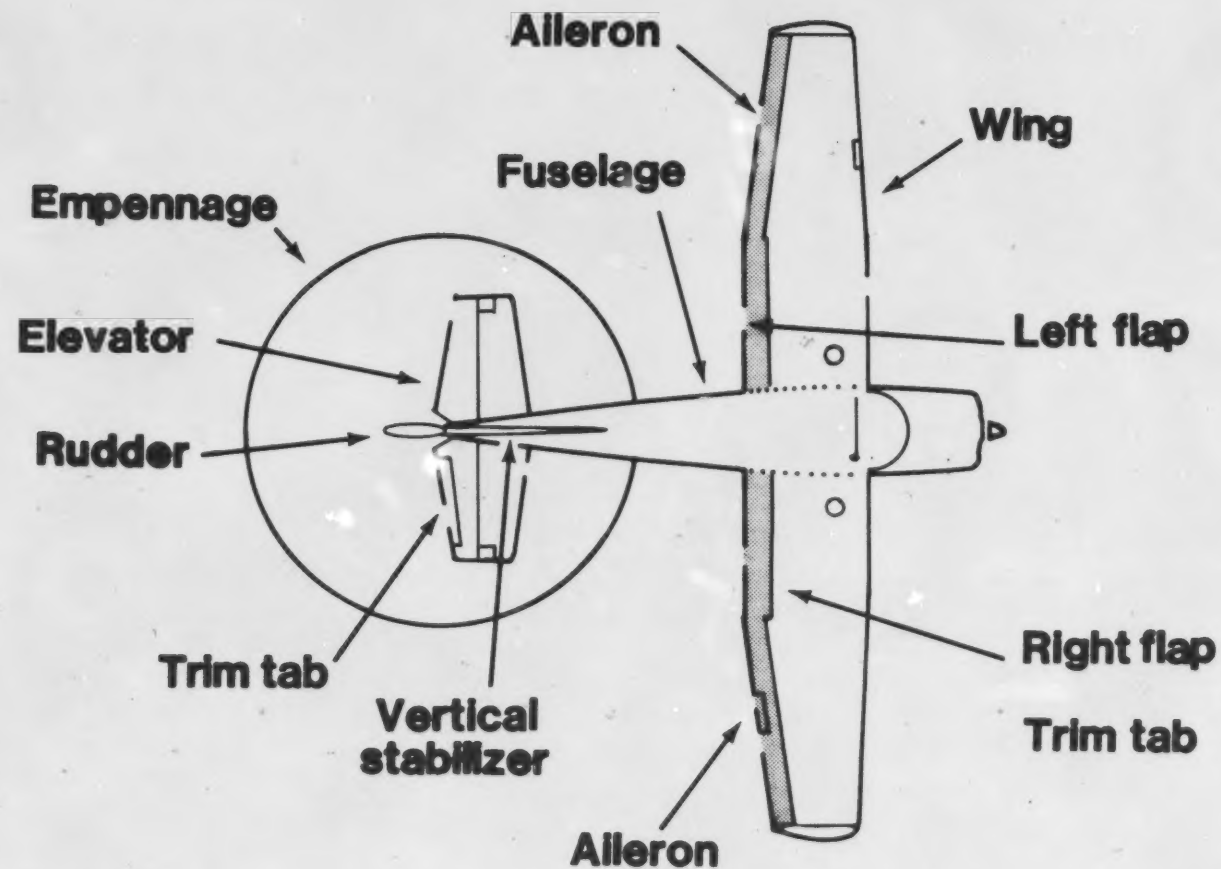
Rocket



Airplane



MAJOR PARTS OF A FIXED WING AIRCRAFT

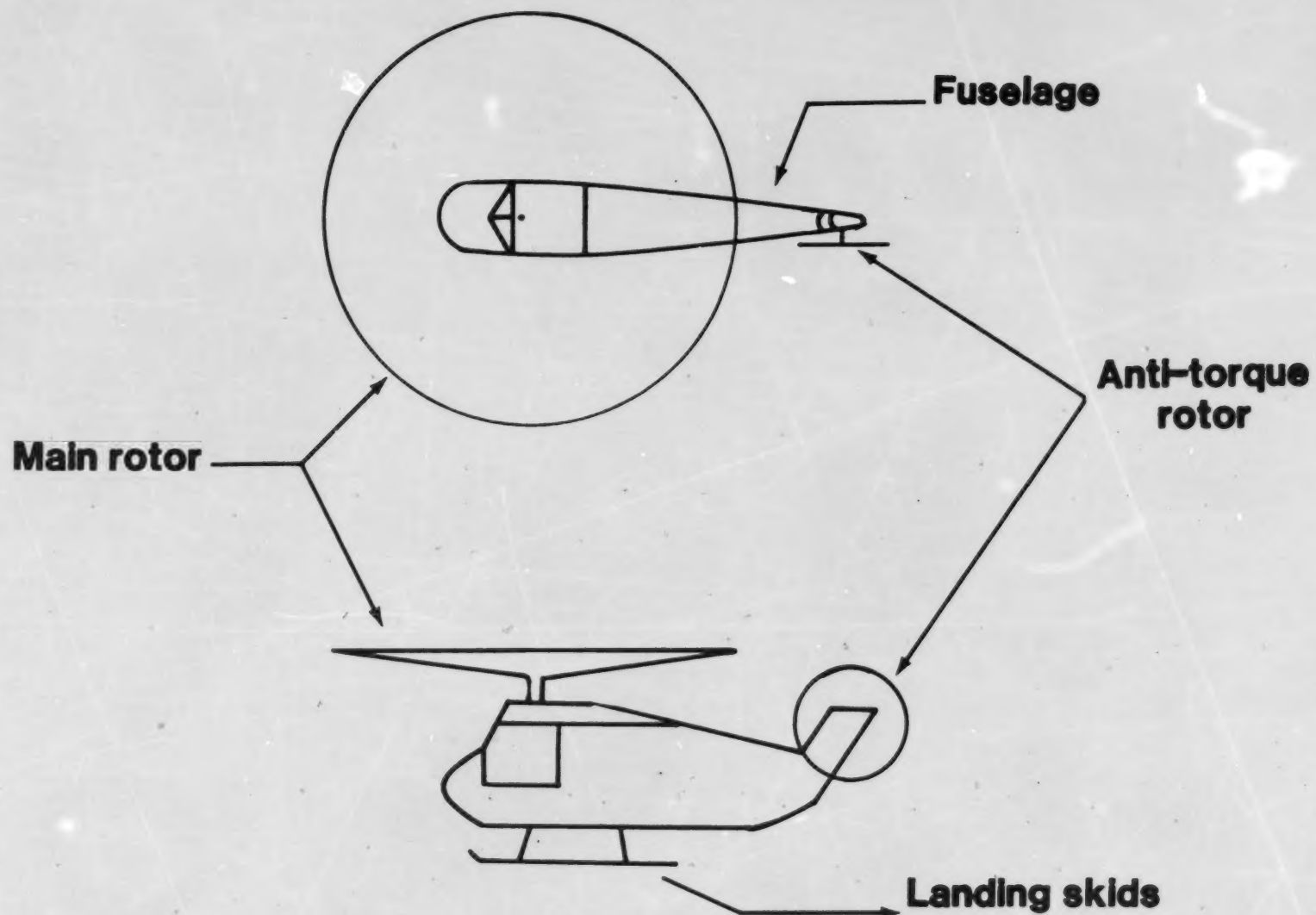


329

330

COURTESY OF CESSNA AIRCRAFT COMPANY/AIR AGE EDUCATION DEPARTMENT

MAIN PARTS OF A ROTARY WING AIRCRAFT



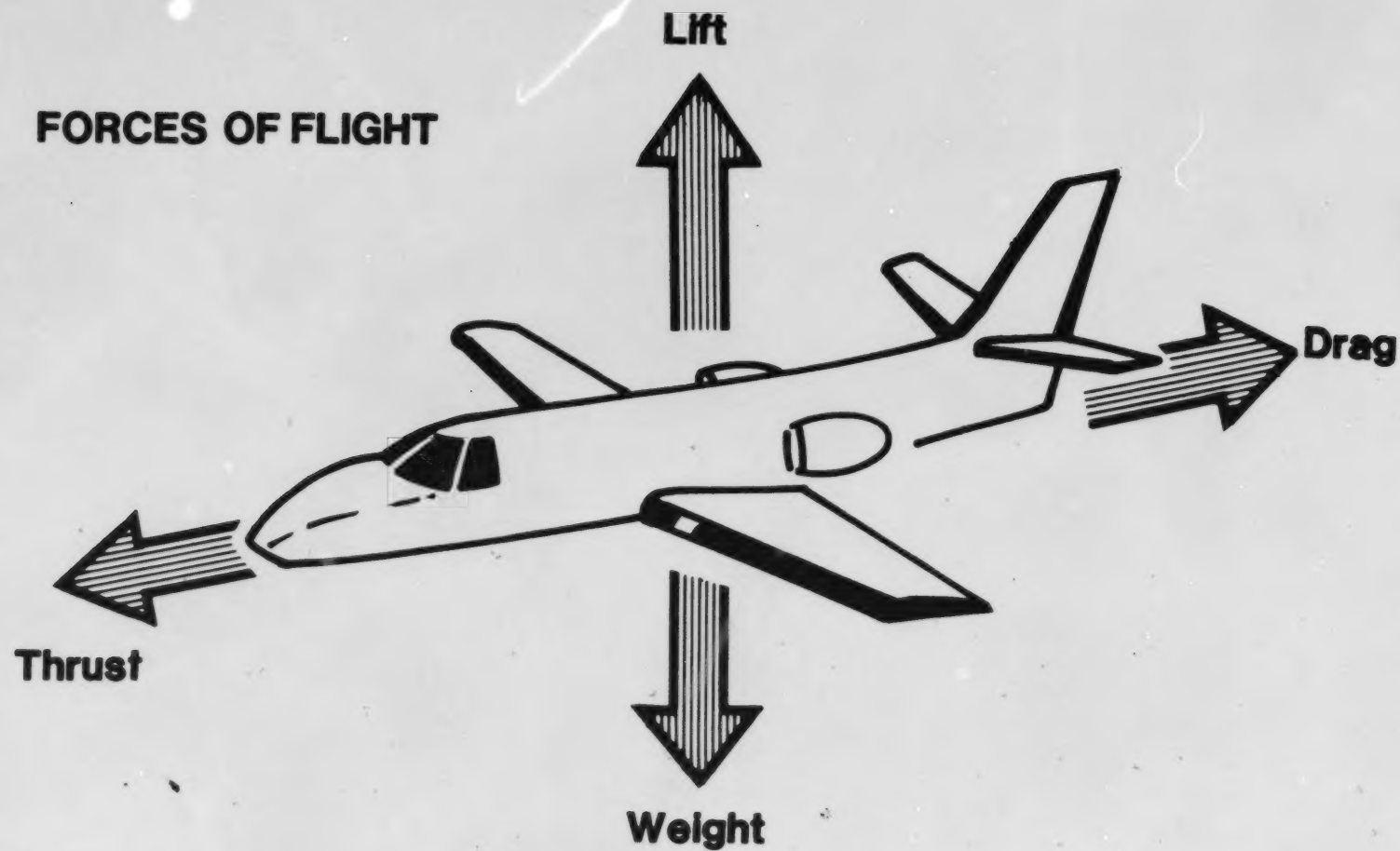
331

332

COURTESY OF CESSNA AIRCRAFT COMPANY/AIR AGE EDUCATION DEPARTMENT

T.M.-4 / AT 4.14-D

FORCES OF FLIGHT

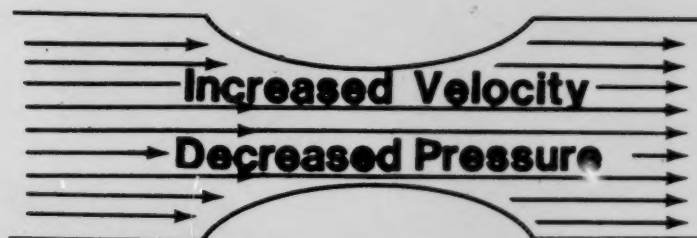


333

334

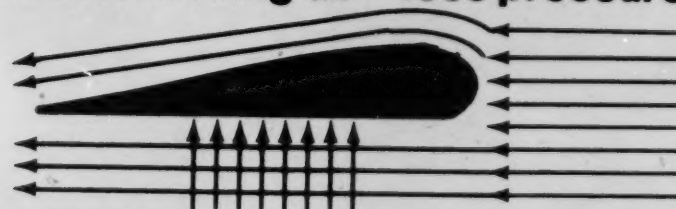
COURTESY OF CESSNA AIRCRAFT COMPANY/AIR AGE EDUCATION DEPARTMENT

WHY AN AIRPLANE FLIES



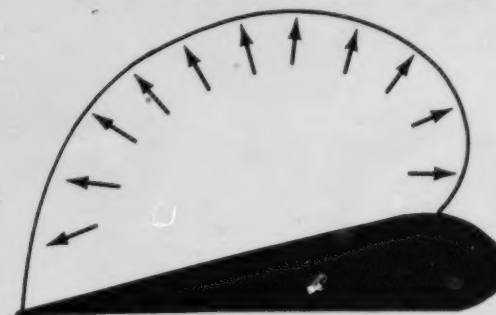
Flow of air through a Venturi Tube demonstrating Bernoulli's Principle

Faster moving air - less pressure



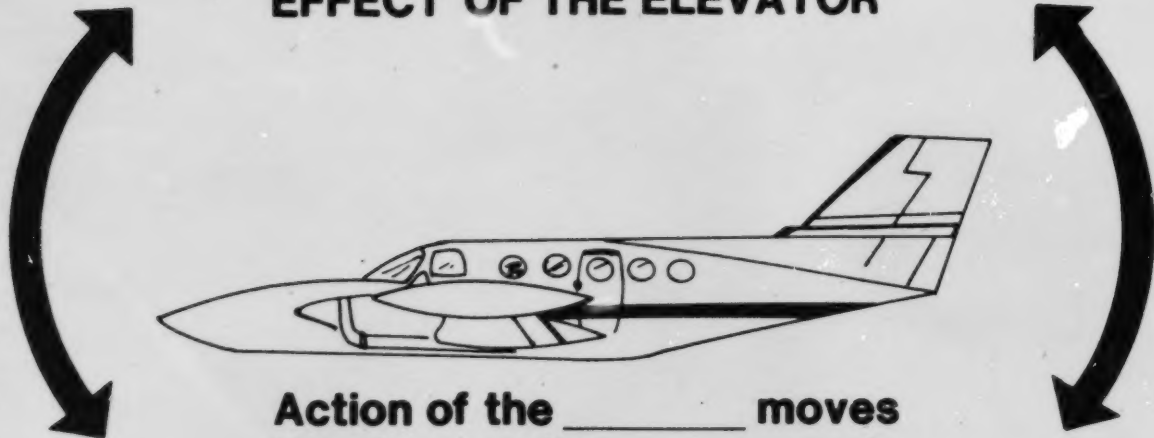
Slow moving air - more pressure

Low pressure area created by air flow over wing

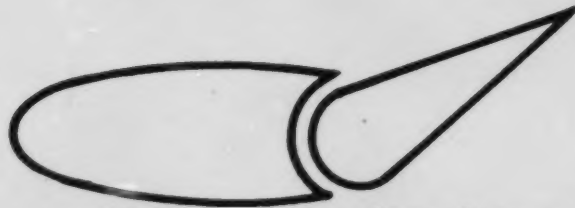


Greater air pressure works here to force wing up into low pressure area producing lift

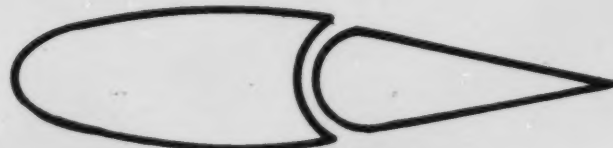
EFFECT OF THE ELEVATOR



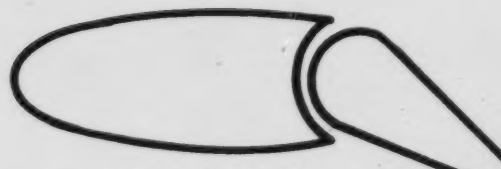
Action of the _____ moves
the plane on its _____ axis



Raising the elevator
forces the tail _____ and the nose _____



Normal lift



Lowering the elevator
forces the tail _____ and the nose _____

elevator
lateral

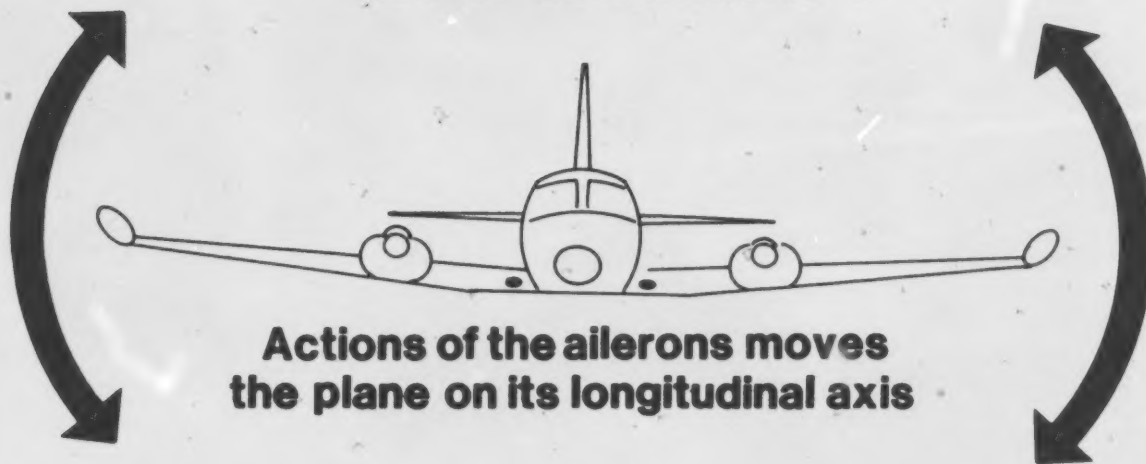
down

up

up

down

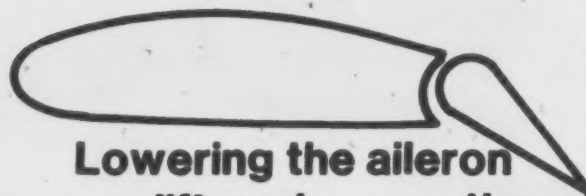
EFFECT OF AILERONS



Actions of the ailerons moves the plane on its longitudinal axis



Normal lift



**Lowering the aileron
_____ lift and _____ the wing**



**Raising the aileron
_____ lift and _____ the wing**

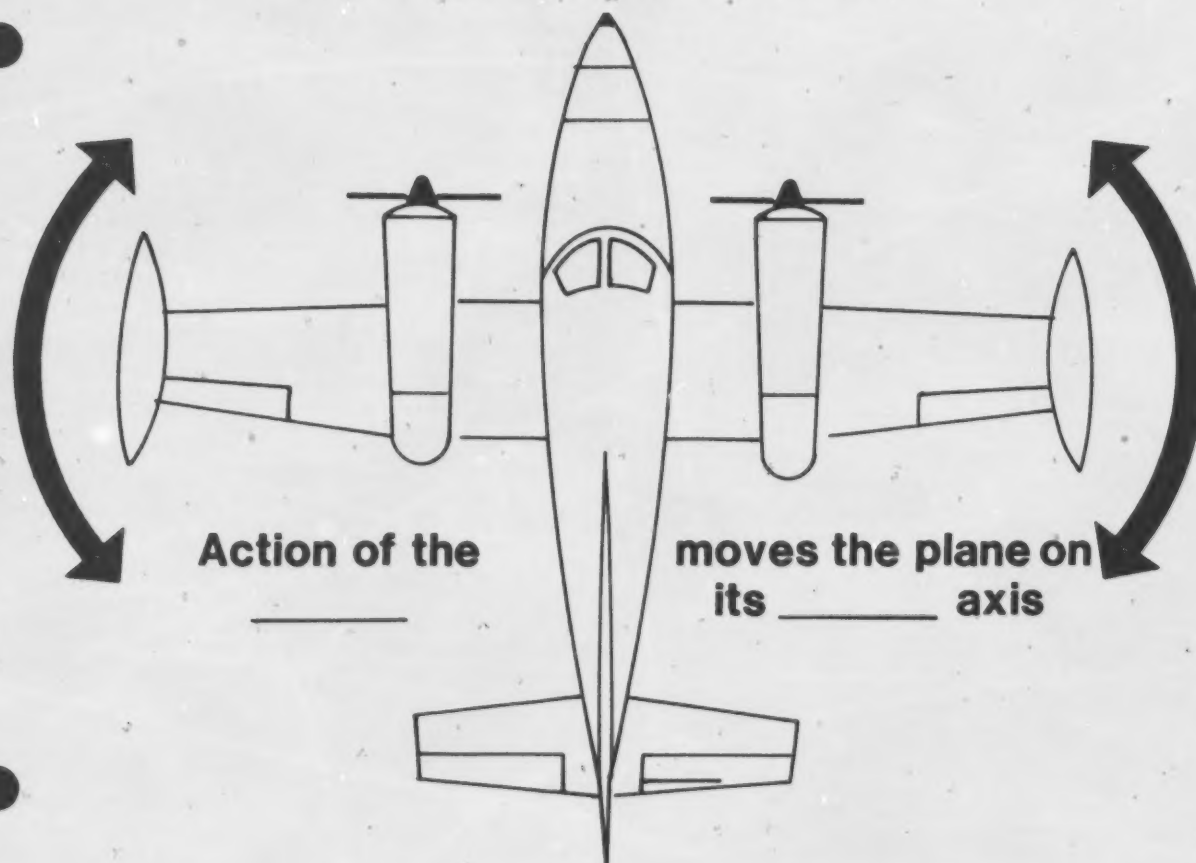
increases

raises

decreases

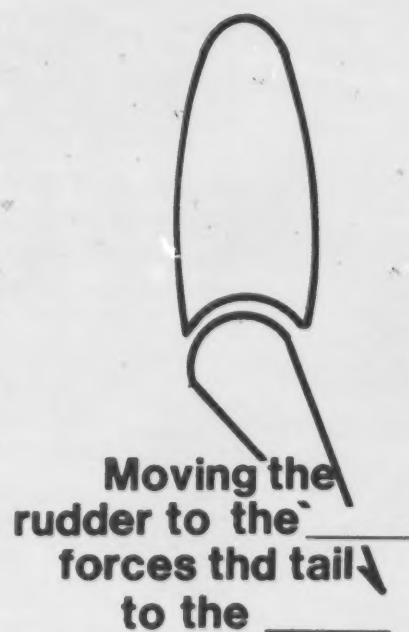
lowers

EFFECT OF THE RUDDER



Action of the _____

moves the plane on
its _____ axis



rudder

vertical

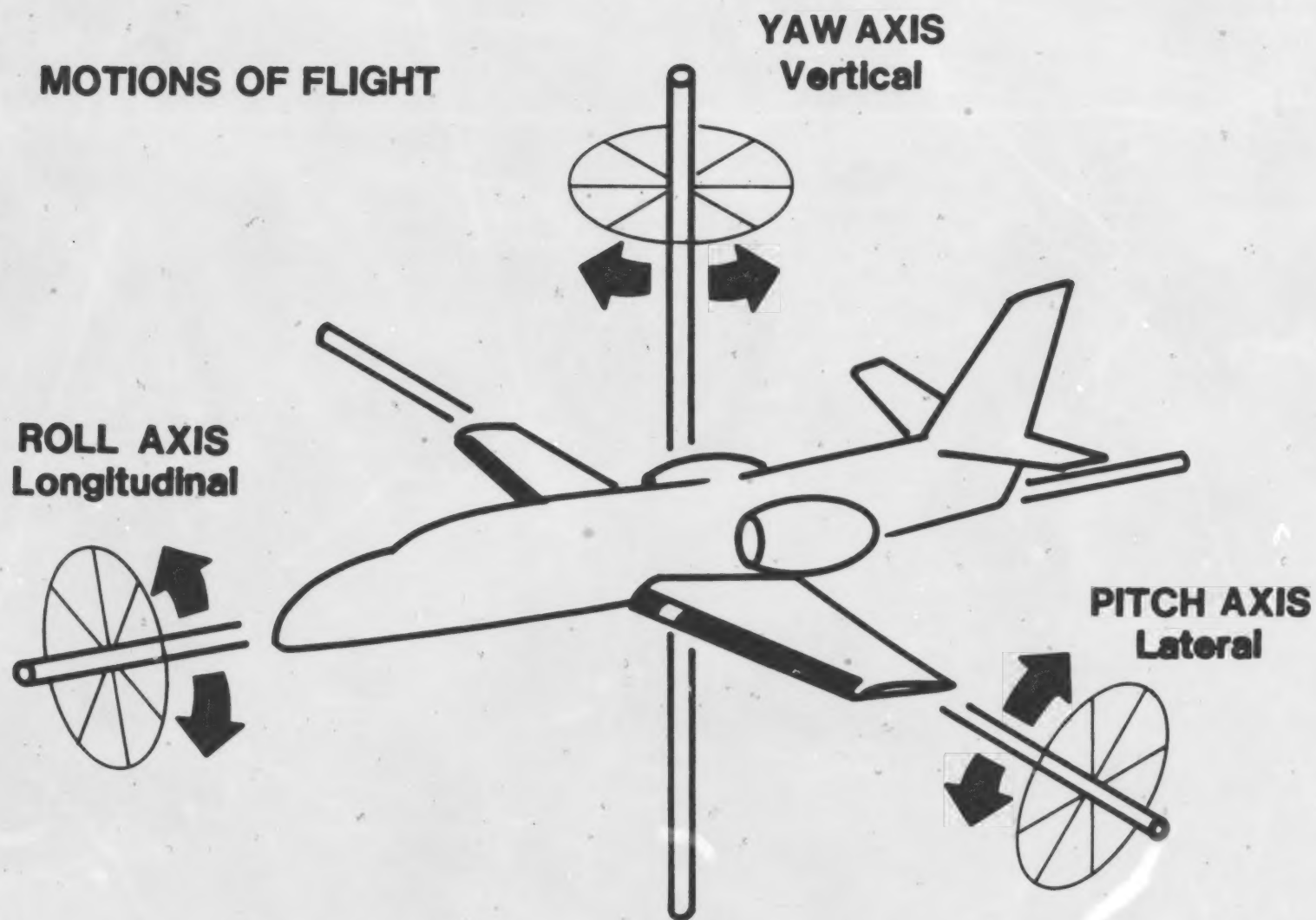
left

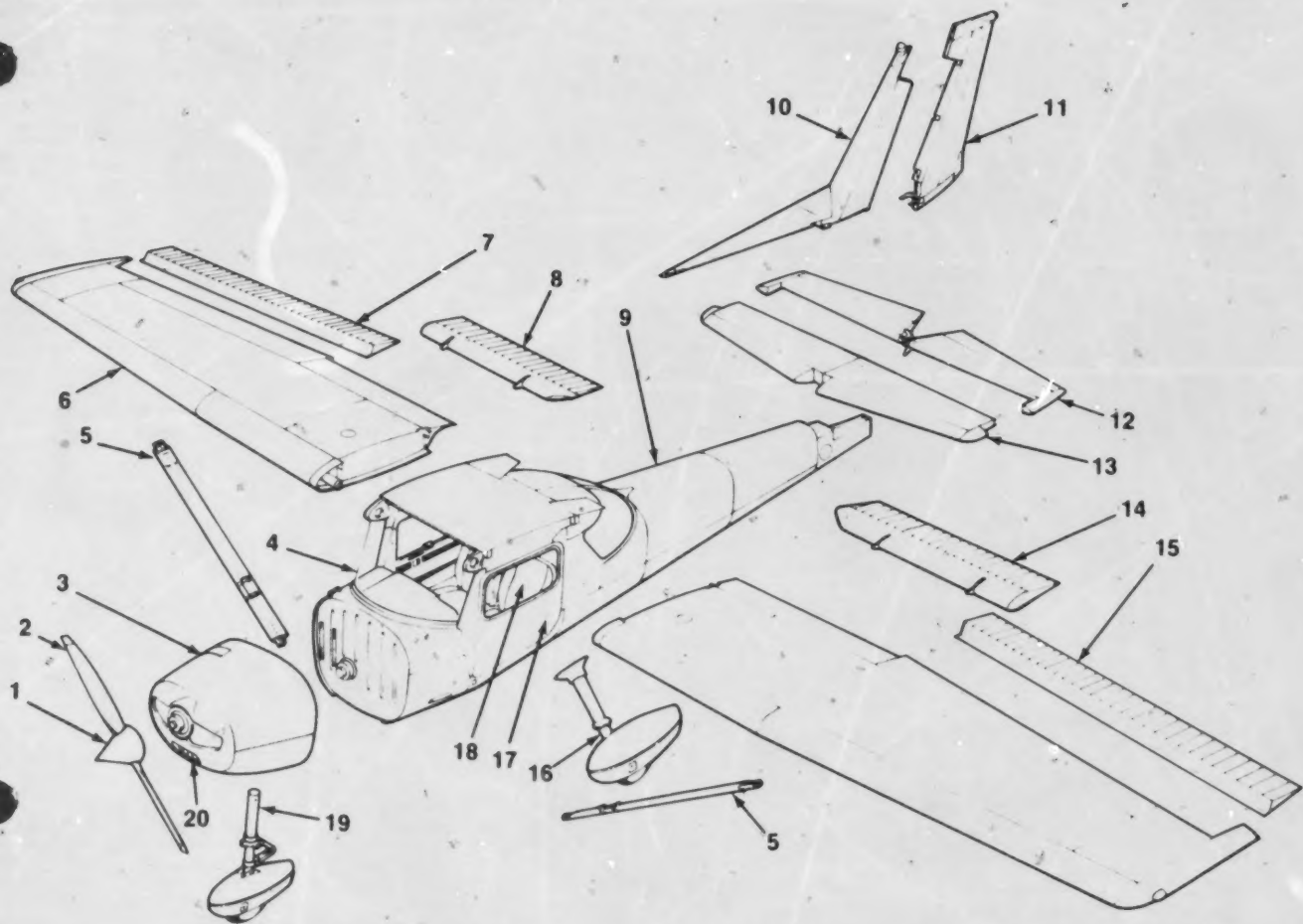
right

right

left

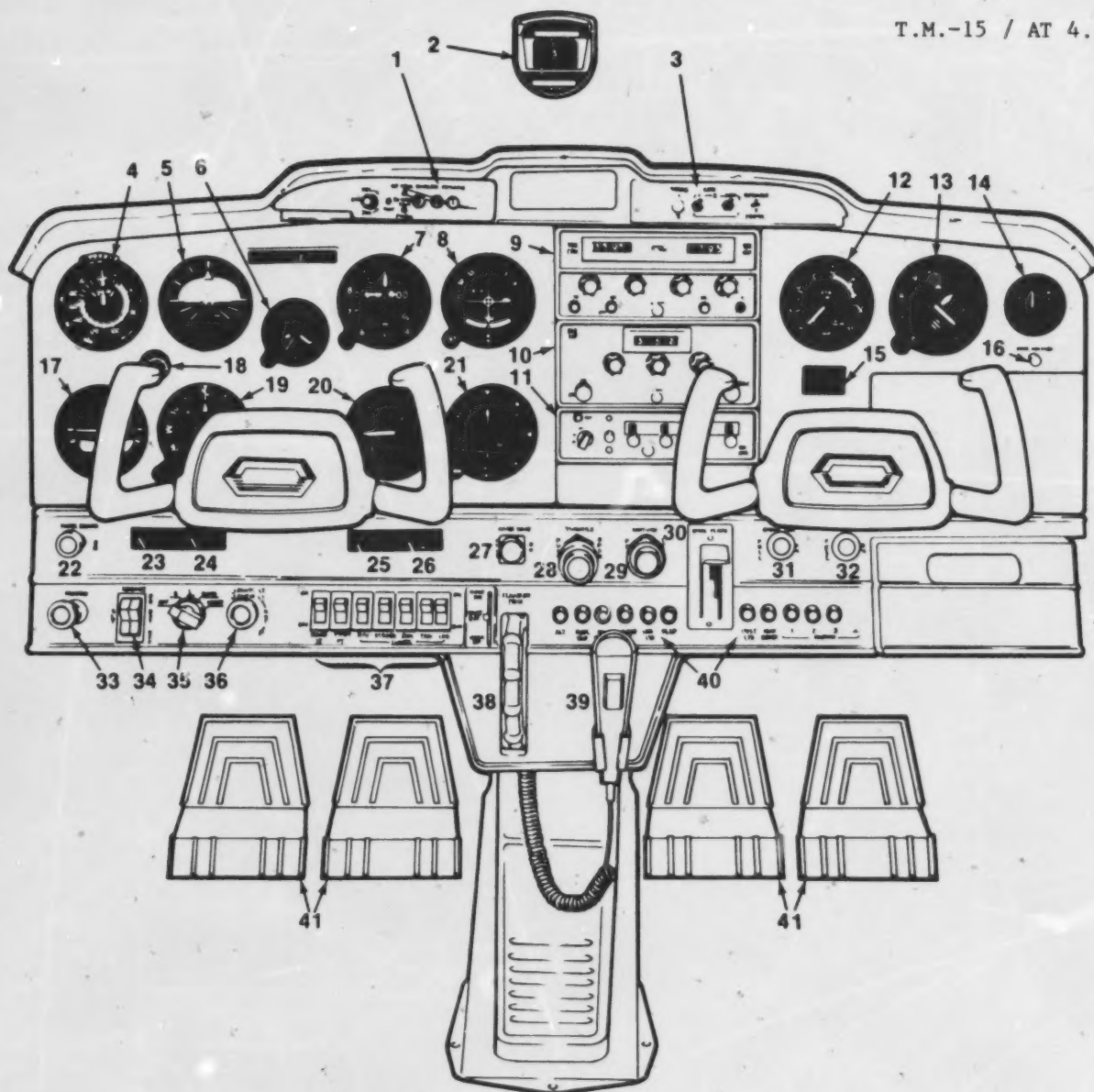
MOTIONS OF FLIGHT





The Main Parts of an Airplane

- | | |
|-------------------------|---------------------------|
| 1. Spinner | 11. Rudder |
| 2. Propeller | 12. Elevator |
| 3. Engine Cowl | 13. Horizontal Stabilizer |
| 4. Windshield | 14. Left Flap |
| 5. Wing Strut | 15. Left Aileron |
| 6. Wing | 16. Main Landing Gear |
| 7. Right Aileron | 17. Door |
| 8. Right Flap | 18. Seat |
| 9. Fuselage | 19. Nose Gear |
| 10. Vertical Stabilizer | 20. Landing Lights |



Instrument Panel

- | | | |
|--|----------------------------------|--------------------------------|
| 1. Marker Beacon Lights | 14. Battery/Alternator Indicator | 28. Throttle Control |
| 2. Magnetic Compass | 15. Hour Meter | 29. Fuel Air Mixture Control |
| 3. Audio Switching Panel | 16. High Voltage Warning Light | 30. Wing Flaps Control |
| 4. Airspeed Indicator | 17. Turn-and-Bank Indicator | 31. Cabin Air Control |
| 5. Altitude Indicator | 18. Suction Indicator | 32. Cabin Heat Control |
| 6. Clock | 19. Heading Indicator | 33. Engine Primer |
| 7. Encoding Altimeter (Electric) | 20. Vertical Velocity Indicator | 34. Master Switch |
| 8. Omni Bearing Selector | 21. ADF Indicator | 35. Ignition Switch |
| 9. NAV/COM (Radio) | 22. Parking Brakes | 36. Panel Light Control |
| 10. Automatic Direction Finder (Radio) | 23. Fuel Gauge (Left Tank) | 37. Interior & Exterior Lights |
| 11. Transponder | 24. Fuel Gauge (Right Tank) | 38. Trim Tab Control |
| 12. Tachometer | 25. Oil Temperature Gauge | 39. Microphone |
| 13. Altimeter (Barometric) | 26. Oil Pressure Gauge | 40. Circuit Breakers |
| | 27. Carburetor Heat Control | 41. Rudder/Brake Pedals |

Demonstration #1

Forces Acting on an Aircraft in Flight

Objective:

To show the student that there are Forces Acting on an Aircraft in Flight. This demo will show lift and weight, thrust and drag. It must be pointed out that when thrust equals drag a constant airspeed will be maintained and when lift equals weight a constant altitude will be maintained. When thrust equals drag and lift equals weight an airplane will remain at a constant airspeed and maintain a constant altitude.

Materials:

1. A folded paper airplane
2. Four rubber bands.

Procedure:

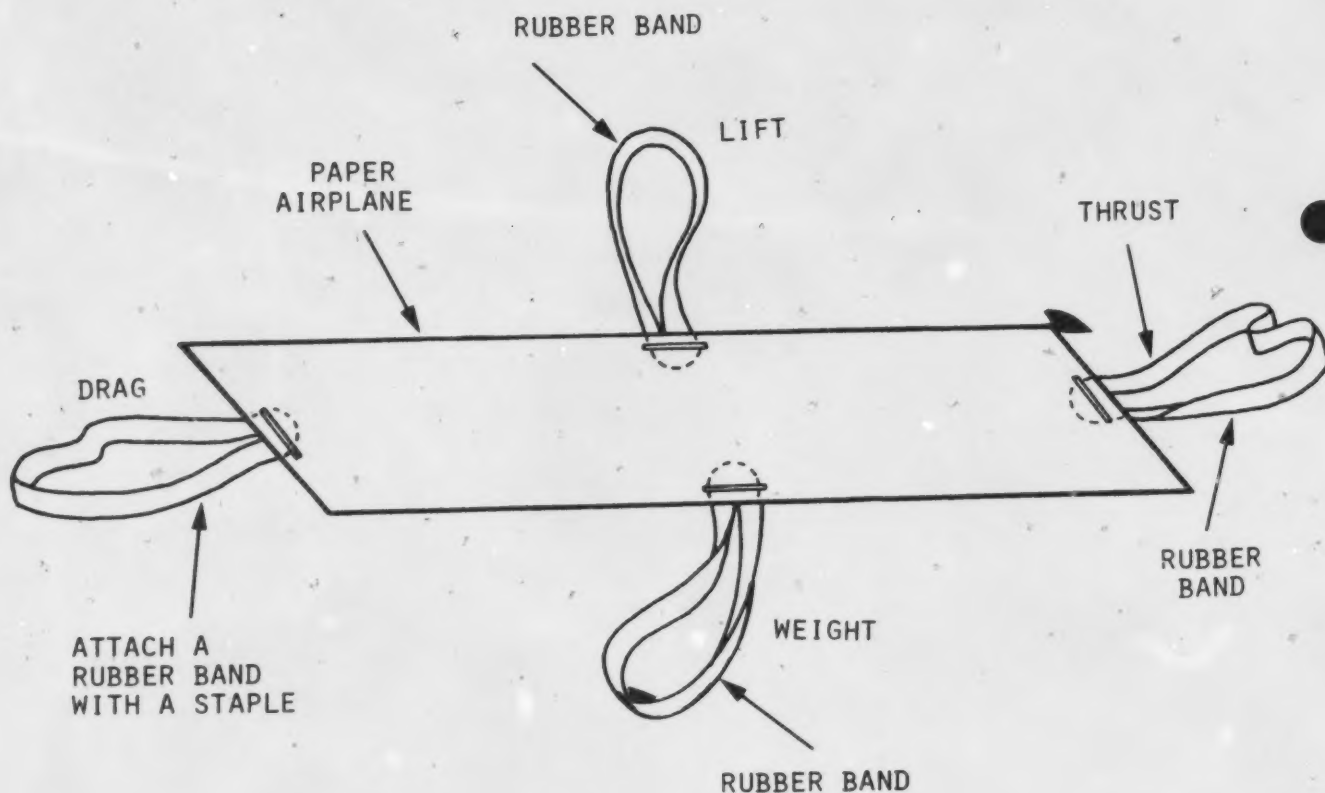
1. Fold a paper airplane using an 8 1/2 x 11 piece of paper.
2. Attach a rubber band to the nose.
3. Attach a rubber band to the tail.
4. Attach a rubber band to the top.
5. Attach a rubber band to the bottom.
6. Hold the rubber band from the nose in one hand and the rubber band from the tail in the other hand.
7. Start to stretch the rubber band in the nose and notice the airplane moves forward until the stretch on the front equals the stretch on the rear band. NOTE: If power is added to the engine the airplane accelerates until thrust equals drag. If power is reduced, the airplane decelerates until thrust equals drag.
8. While holding thrust and drag equal, have a student hold the top rubber band in one hand and the bottom rubber band in the other hand. Pull up on the top rubber band and note that the airplane moves up until the stretch on the top rubber band equals the stretch on the bottom rubber band. NOTE: If lift is increased, the airplane climbs until the lift equals weight. Consequently, if airlift is increased, the aircraft descends and continues to do so until weight equals lift.

Principle:

This demo will show lift and weight, thrust and drag. It must be pointed out that when thrust equals drag, a constant airspeed will

be maintained and when lift equals weight a constant altitude will be maintained. When thrust equals drag and lift equals weight, an airplane will maintain a constant airspeed at a constant altitude. All of these forces, however, are interchangeable in that altitude may be sacrificed for airspeed and vice versa. Consequently, the nose position will control airspeed and the throttle will control altitude.

"GRAPHIC REPRESENTATION"



Demonstration #2

Demonstration of Lift Using Bernoulli's Principle

Objective:

To show students that the air moving over a surface produces a low pressure area if it moves faster over one surface than the other.

Materials:

1. 8 1/2 X 11 sheet of notebook or typing paper.

Procedure:

1. Hold the paper by either of the 8 1/2" ends. The far end curves downward.
2. Blow gently across the top of the paper.
3. Notice how the paper rises into the low pressure area.

Hot Air Balloon

Objective:

You will take the materials given and correctly make a hot air balloon.

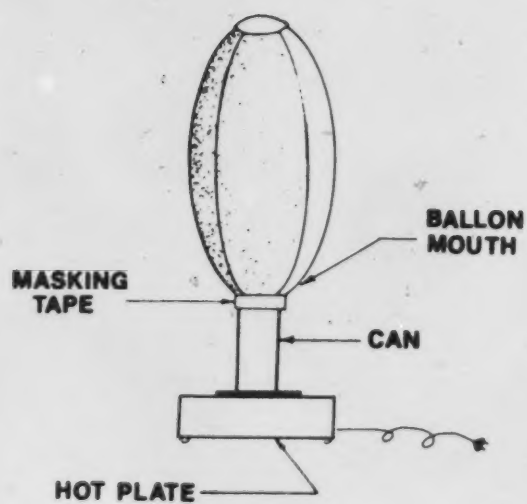
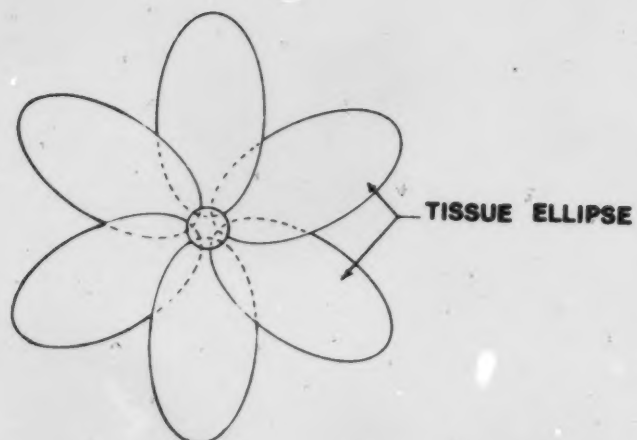
Materials:

1. Tissue paper
2. Scissors
3. Tin can (Size 303)
4. Hot plate
5. Can opener
6. Cotton string
7. Rubber cement
8. Masking tape

Procedure:

1. Cut both ends from the can.
2. Cut from the tissue paper a circle and six elliptical sections whose relative dimensions are approximately 3-1.
3. Paste the edges of the sections together overlapping them at one end and fastening them to the circle.
4. Reinforce the opening left at the other end with a 1" collar of masking tape.
5. Fill the balloon with hot air rising through the can which has been placed on the hot plate.
6. Tether with light cotton string to control its flight.

HOT AIR BALLON



Aircraft Nomenclature

Objective:

You will take the materials given and correctly name the main parts of an airplane.

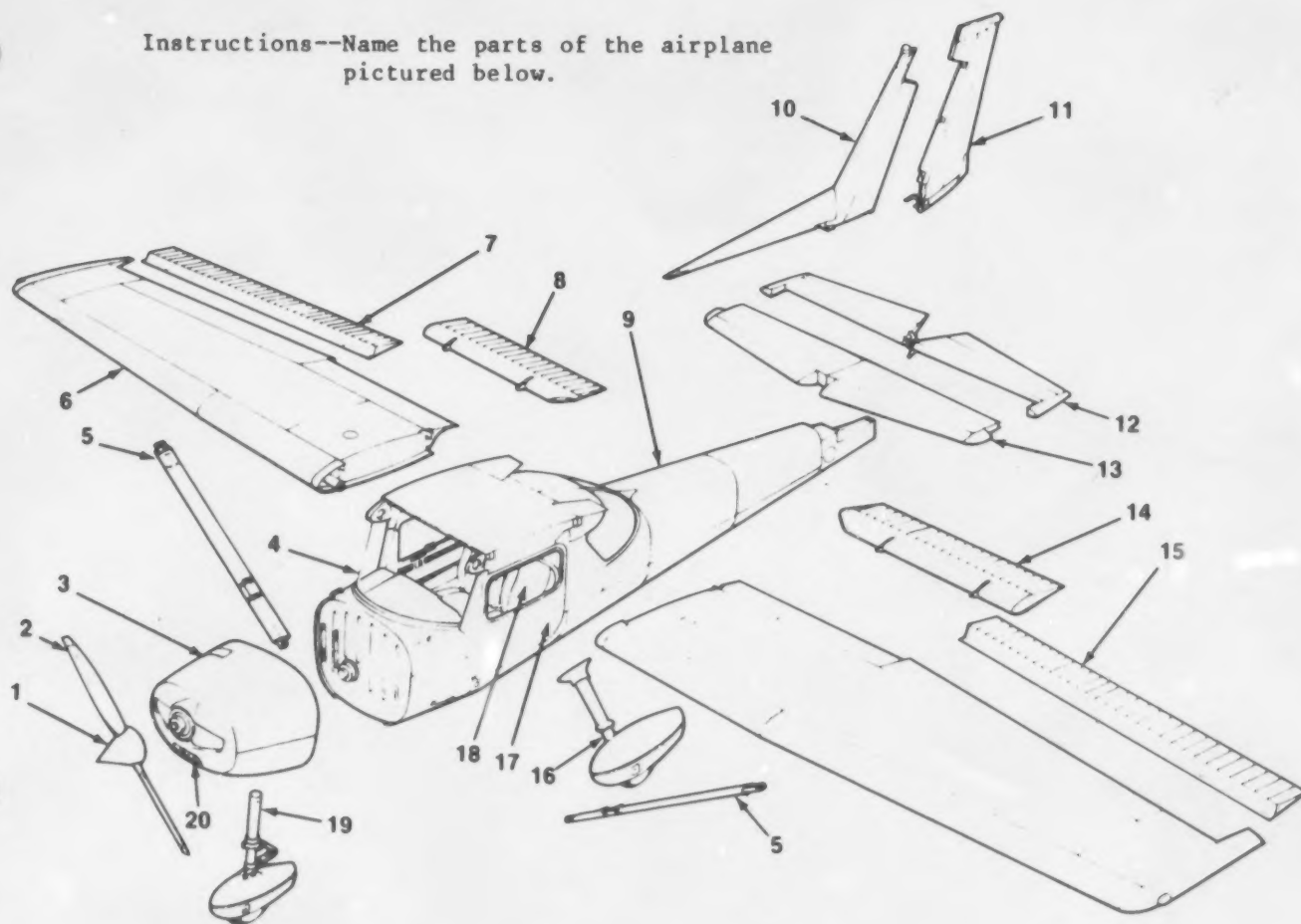
Materials:

1. One exploded view of an aircraft.

Procedure:

1. Complete the blanks naming the main parts of an aircraft.
2. Check the answers against a master.

Instructions--Name the parts of the airplane
pictured below.



- | | |
|-----------|-----------|
| 1. _____ | 13. _____ |
| 2. _____ | 14. _____ |
| 3. _____ | 15. _____ |
| 4. _____ | 16. _____ |
| 5. _____ | 17. _____ |
| 6. _____ | 18. _____ |
| 7. _____ | 19. _____ |
| 8. _____ | 20. _____ |
| 9. _____ | 21. _____ |
| 10. _____ | 22. _____ |
| 11. _____ | 23. _____ |
| 12. _____ | 24. _____ |

The Main Parts of an Airplane

- | | |
|--------------------------|---|
| 1. Spinner | 13. Left Wing Aileron |
| 2. Landing Gear | 14. Door |
| 3. Wing Strut | 15. Seat |
| 4. Wing | 16. Windshield |
| 5. Right Wing Aileron | 17. Engine Cowl |
| 6. Right Wing Flap | 18. Propeller |
| 7. Fuseleage | 19. Elevator Trim Section |
| 8. Horizontal Stabilizer | 20. Right Wing Clearance
Light (Green) |
| 9. Fin and Dorsal | 21. Left Wing Clearance
Light (Red) |
| 10. Rudder | 22. Landing Light |
| 11. Elevator | 23. Tail Clearance Light
(White) |
| 12. Left Wing Flap | 24. Anti-collision Light
(Flashing Red or White) |

Student Activity #3

The Air Transportation System Vehicle

Objective:

You will take the materials given and correctly build a model of an aircraft.

Materials:

1. One model airplane kit (plastic)
2. Glue
3. Paint

Procedure:

1. Obtain a model (plastic) kit of an airplane.
2. Build the model in accordance with instructions.
3. Paint if desired.
4. Research performance information about your aircraft, its uses and era of use.
5. Give an oral report, or write a paper on your model.

(Note to the Teacher: Recommend you specify kit and try to have each student obtain a different kit. Try to use discretion in regard to different wing types, no. of engines and classification. Some rotary wing also.)

The Air System in Action

Objective:

You will take your completed model and walk it through the airway system you have previously constructed in the classroom.

Materials:

None except the use of already completed project.

Procedure:

1. Establish a Classroom Control Center.
2. Man control towers and approach controls.
3. File flight plans with the appropriate airport control facilities.
4. Obtain a clearance from ATC.
5. Obtain take-off clearance.
6. Walk through the clearance as given by Classroom Center.

(Note: If your school has a language lab you may pass clearances to each other utilizing the headphones and microphones.)

A SAMPLE CLEARANCE NARRATIVE

Your aircraft is November Charlie 64123. Your flight plan calls for a departure from Maple City Municipal Airport via (by way of) the Maple City VOR Victor 81 to Cookville, Victor 73 Nashville, Victor 45 Sand Bar Municipal. Your requested altitude is 8000.

You call Maple City Ground Control initially:

NC 64123	Maple City Ground Control, November Charlie 64123, Cessna 172 IFR Sand Bar, Taxi 1.
MCGC	Roger November Charlie 64123, Taxi Runway 24, Altimeter 30.16, Wind 240° 10 knots. Call on this frequency for clearance.
NC 64123	Maple City Ground Control, November Charlie 64123 ready to copy clearance.

MCGC Roger November Charlie 64123, ATC clears November Charlie 64123 to the Sandbar Municipal Airport via V81 Cookville, V73 Nashville, V45 Sandbar Direct Sand Bar Municipal. Climb to and maintain 8000. After take off turn left and proceed direct the Maple City VOR Climb on course. Contact Classroom Center on 128.75 reaching 8000. Contact Maple City Departure on 126.4 after takeoff. Read back.

NC 64123 "Read back the clearance exactly as given"

MCCC Roger NC 64123, your readback is correct--Contact Maple City Tower on 124.2 when ready for takeoff.

NC 64123 Roger ground, 64123 Switching. Maple City Tower, November 64123 is ready for takeoff.

MC Tower Roger 64123, Taxi into position and hold Runway 24.

MC Tower November Charlie 64123, Wind 243° 8 Knots. You are cleared for takeoff Runway 24. Contact Maple City Departure Control on 126.4 when safely airborne. Acknowledge.

NC 64123 Roger Maple City Tower, November Charlie 64123 rolling.

NC 64123 Maple City Departure Control this is November Charlie 64123.

MCDC Roger November Charlie, This is Maple City Departure Control, I have you in radar contact. You are cleared to turn left and proceed direct to the Maple City VOR. When out of turn you will have traffic at 3 o'clock 6 miles.

MCDC November Charlie 64123, I have you passing Maple City VOR. Continue on course, Continue climb to 8000. Contact Classroom Center now on 128.75.

NC 64123 Roger Maple City Departure Control, November Charlie 64123 switching. Classroom Center, this is November Charlie 64123 reaching 8000.

CC Roger NC 64123, Squawk 1500 IDENT. Roger I have you in radar contact, Maintain 8000.

CC November Charlie 64123, Contact Classroom Center now on 128.45.

CC November Charlie 64123. Contact Sand Bar Approach Control on 122.3

NC 64123 Roger this is NC 64123 switching--Sand Bar Approach Control, this is Nc 64123 inbound 8000, over.

AT 4.24

SBAC Roger November Charlie 64123, this is Sand Bar Approach Control, You are cleared for an ILS Approach landing Runway 6. Sky is measured 400 feet overcast, one and one half miles visibility, light rain and snow. Wind is 060° 15 Knots with gusts to 25. Contact the tower on 121.6 over the outer marker inbound.

NC 64123 Roger November Charlie 64123, out.

NC 64123 Sand Bar Tower this is November Charlie 64123, ILS outer marker, inbound.

Sand Bar T Roger November Charlie 64123, Outer Marker inbound, you are cleared to land Runway 6. Wind now 060° 4 Knots.

Sand Bar T November Charlie 64123, we observe you rolling out. You are cleared right off next intersection. Contact Ground Control on 129.2 when clear of the runway.

NC 64123 Roger Tower, NC 64123 turning off and switching. Sand Bar Ground NC 64123 clear of the duty.

Sand Bar Gr Roger NC 64123. Continue taxiing straight ahead to the next intersection, turn left and pick up your taxi director-- Cleared to the ramp.

NC 64123 Roger Ground, November Charlie 64123, Out.

"Aircraft Design"

Objective:

You will take the materials given and correctly fold a paper airplane.

Materials

1. One sheet of 8 1/2 x 11 paper.
2. Stapler
3. Paper clips
4. One penny
5. Scotch tape
6. Glue

Procedure

1. Design and fold a paper airplane. If desired use staples, paper clips, scotch tape and/or glue.
2. Use penny and paper clips to add weight to nose of the aircraft.
3. Fly aircraft and note the flight path.
4. Place tabs, etc. on your aircraft and change weight if desired. Note the different changes in the flight path as you change the trim. Try to make the airplane roll in different directions, climb, glide or do acrobatics as you desire.
5. Write a narrative report on your findings and explain why your airplane reacted as it did. Hand the report to your teacher.

"Flight Contest"

Objective:

You will take the materials given and conduct a flight contest.

Materials:

1. One balsa or styrofoam model aircraft
2. One paint kit.
3. Glue (if required)
4. One time sheet/distance sheet
5. 1 stop watch

Procedure:

1. By vote of the class and with approval of your instructor, decide on a balsa or styrofoam model airplane kit.
2. Decide either to divide the class in groups or to participate as individuals.
3. Elect an official time keeper and referee.
4. Have each group/individual purchase the same kit.
5. Build the kit in accordance with the instructions.
6. If you desire, paint your airplane.
7. Find a place to fly your airplanes where the distance can be measured. (Suggest the football field.)
8. Determine the wind direction. (Note: This can be done by throwing up a blade of grass and observing the direction of travel.)
9. Set up a contest for duration of flight. Locate a starting point and launch the airplane "INTO" the wind. Have the time keeper punch the stop watch when the aircraft leaves the launcher's hand, and again when the aircraft touches the ground. Record the time.
10. Determine the student whose airplane stayed airborne the longest amount of time.

11. Set up a contest for distance of flight. Locate a starting point and launch the airplane "WITH" the wind. Have someone measure the distance and let the time keeper record it. Measure total distance from launch point to where the aircraft came to rest.
12. Determine the student whose airplane traveled the farthest.
13. Make an award to the winner/winners if desired.
14. Write a short paper on the effect the wind has over the actual flight path of the airplane over the ground. Give the paper to your instructor for evaluation.

Rocket Travel

Objective:

You will take the materials given and correctly build a rocket.

Mataerials:

As listed in the Laboratory Manual of the "World of Manufacturing" starting on page 14.

Procedure:

1. Follow and build the rocket in accordance with the instructions given in the Laboratory Manual.
2. Fly the rocket.
3. Write a paper telling how a system of rocket travel (such as the space shuttle) might differ from an air transportation system. What navigational problems might be encountered? How could these problems be solved? What guidance, landing and docking problems can you foresee? What fuel problems and re-fueling problems might exist? Do you think that someday man may have a rocket transportation system to travel between planets?

SUGGESTED TEST

1. An/A _____ or _____ is a steerable self propelled aircraft and is lighter-than-air.
 - a. Airplane or helicopter
 - b. Blimp or airplane
 - c. Dirigible or airship
 - d. Dirigible or airplane
2. An/A _____ is a free floating airtight bag that rises above the earth when filled with hot air or a gas lighter-than-air, such as hydrogen or helium.
 - a. Balloon
 - b. Blimp
 - c. Airship
 - d. Sputnik
3. An/A _____ is a heavier-than-air aircraft with a fixed wing.
 - a. Airship
 - b. Airplane
 - c. Rocket
 - d. Helicopter
4. An/A _____ is a heavier-than-air aircraft with a rotary wing.
 - a. Airship
 - b. Airplane
 - c. Rocket
 - d. Helicopter
5. The _____ of the wing occurs because of a phenomenon known as Bernoullis' principle.
 - a. Shape form
 - b. Total length
 - c. Pressure differential
 - d. Total width
6. In order for an aircraft to maintain level flight, thrust must equal _____, and lift must equal _____.
 - a. Drag, thrust
 - b. Weight; drag
 - c. Lift, weight
 - d. Drag, weight

7. Movement of an aircraft about the _____ axis is called roll.
- a. Longitudinal
 - b. Lateral
 - c. Vertical
 - d. Lengthwise
8. Movement of an aircraft about the _____ axis is called pitch.
- a. Longitudinal
 - b. Lateral
 - c. Vertical
 - d. Lengthwise
9. Movement of an aircraft about the _____ axis is called yaw.
- a. Longitudinal
 - b. Lateral
 - c. Vertical
 - d. Lengthwise
10. _____ is controlled by the ailerons.
- a. Roll
 - b. Pitch
 - c. Yaw
 - d. Bank
11. _____ is controlled by the elevator.
- a. Roll
 - b. Pitch
 - c. Yaw
 - d. Bank
12. _____ is controlled by the rudder.
- a. Roll
 - b. Pitch
 - c. Yaw
 - d. Bank
13. Control pressure required to move the _____ is reduced by the use of trim tabs.
- a. Right dihedral
 - b. Wing spar
 - c. Control surfaces
 - d. Coffee pot

14. In addition to control about the vertical axis, the _____
_____ also control the brakes.
- a. Engine throttles
 - b. Ailerons
 - c. Rudder pedals
 - d. Rear wheels
15. The _____ moves fore and aft, left and right and controls the
elevator and the ailerons.
- a. Stick or yoke
 - b. Rudder pedals
 - c. Throttle
 - d. Attitude gyro

ANSWERS TO TEST

1. C
2. A
3. B
4. D
5. C
6. D
7. A
8. B
9. C
10. A
11. B
12. C
13. C
14. C
15. A

EQUIPMENT/SUPPLIES

- 1 small plastic model airplane
- 1 box rubber bands
- 1 sheet 8 1/2 X 11 typing paper
- 1 pkg tissue paper
- 6 pair scissors
- 6 tin cans (Size 303)
- 6 hot plates
- 6 can openers
- 1 roll light cotton string
- 1 jar rubber cement
- 1 roll masking tape
- 24 exploded views of the major parts of an aircraft
- 6 exploded view (Keys)
- 24 model airplane kits
- 24 tubes glue (Model Airplane)
- 24 assorted paint kits

TENNESSEE INDUSTRIAL ARTS CURRICULUM

Instructional Section:
AIR TRANSPORTATION SYSTEM

Title of Unit:
PRE-TEST/POST-TEST

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PRE-TEST/POST-TEST

This test is to be administered before the course begins and again after the course has ended.

Multiple Choice:

1. The transportation of mail, cargo or people is known as:
 - a. Air mail
 - b. Air carriers
 - c. Air transportation
 - d. Air ways
2. Any device that is used or intended for flight in the air is known as an:
 - a. Aircraft
 - b. Airplane
 - c. Air vehicle
 - d. Fighter plane
3. The field or lake upon which airplanes land and take off including the facilities is called an/a:
 - a. Runway
 - b. Taxiway
 - c. Air terminal
 - d. Airport
4. The designated and identified air corridor through which aircraft flow from one destination to another is called a/an:
 - a. Air lane
 - b. Air corridor
 - c. Airway
 - d. Air route
5. An engine driven lighter-than-air craft which can be steered is called a/an:
 - a. Balloon
 - b. Airship
 - c. Airplane
 - d. Helicopter
6. An airplane that can land on both land and water is called:
 - a. A float plane
 - b. A sea plane
 - c. An amphibian
 - d. A helicopter

7. Voice directions to airplanes in flight are transmitted from controllers to pilots by way of:
 - a. Telephone lines
 - b. Two-way radios
 - c. Semaphore flags
 - d. Flashing lights
8. The agency for setting up and maintaining the airways is:
 - a. Federal Aeronautical Association
 - b. Federal Airway Association
 - c. Federal Airplane Arrangement
 - d. Federal Aviation Administration
9. Aircraft navigate over the airways by following:
 - a. The pilots nose
 - b. Railroads and highways
 - c. Very high frequency omni range stations
 - d. Dead reckoning
10. The removal and overhaul of an engine would be performed by:
 - a. The Aircraft Maintenance Dept
 - b. The Air Scheduling Officer
 - c. The Aircraft Controller
 - d. The Operations Department

Completion:

11. A fixed wing heavier-than-air craft is called an _____.
12. The large rotor on top of a helicopter is called the _____ rotor.
13. An aircraft which has no wings is called a _____.
14. Carry-on luggage taken aboard an aircraft will be checked through a/an _____ machine.
15. The gas now used to inflate an airship is called _____.

True/False:

16. T F An airship which has a rigid inner structure is called a blimp.
17. T F The two sets of rules under which aircraft fly are called instrument flight rules (IFR) and visual flight rules (VFR).

AT 5.4

18. T F Clearance for an aircraft to taxi on the airport comes from departure control.
19. T F Takeoff clearance is given to an airplane by the Control Tower.
20. T F The lowest altitude which an airplane can fly and still maintain 1000' above the highest obstacle within a radius of 25 miles is known as the minimum enroute altitude.

Matching:

- | | |
|-----------------|----------------|
| 21. roll | A. small rotor |
| 22. pitch | B. weight |
| 23. yaw | C. elevator |
| 24. anti-torque | D. aileron |
| 25. lift | E. rudder |

26-30. (Optional) Essay:

"Write a short paragraph on the three major components of the Air Transportation System."

MASTER MATERIAL LIST

1. 6 airline schedules to a given destination
2. 6 bus schedules to the same given destination
3. 1 magnetic compass
4. 1 chalkboard drawing compass
5. 6 small drafting compasses
6. 6 straight edges
7. 24 protractors
8. 12 rolls 1/4" masking tape
9. 7 road maps of your state
10. 24 enroute planning logs
11. 24 route plan sheets
12. 24 4" X 4" X 4" pine blocks
13. 24 12D nails
14. 24 2" X 2" X 6" pine blocks
15. 1 small wood turning lathe and tools
16. 24 6" X 6" white poster board
17. 6 pair scissors
18. 1 bottle black ink
19. 1 pint white paint (enamel or latex)
20. 24 2' X 2' X 1/4" plywood boards
21. 1 quart green paint
22. 1 quart black or gray paint
23. 1 pint yellow paint
24. 24 architect scales
25. construction paper
26. assorted paint brushes

AT 5.6

- 27. assorted pens
- 28. 1 yardstick
- 29. 1 pack 8 1/2 x 11 white paper
- 30. 24 sheets white paper 11 x 17
- 31. 24 flight plans
- 32. 24 flight plan logs
- 33. 1 small plastic model airplane
- 34. 1 box rubber bands
- 35. 1 package of tissue paper
- 36. 6 tin cans (size 303)
- 37. 6 small hot plates
- 38. 6 can openers
- 39. 1 roll light cotton string
- 40. 1 jar rubber cement
- 41. 24 exploded views of the major parts of an aircraft
- 42. 6 exploded view (Key)
- 43. 24 model airplane kits
- 44. 24 tubes glue (model airplane as specified in kits)
- 45. 24 assorted paint kits (recommend Testors)
- 46. 1 bottle rubber cement

TRANSPORTATION

JOB STRUCTURE: AIR

JOB TITLE: Aerodynamist

D.O.T. No.: 002 061 010

Major Job Function:

Plans and conducts analysis of aerodynamic, thermodynamic, aerothermodynamic, and aerophysics concepts, systems, and designs to resolve problems and determine suitability and application to aircraft, space vehicle, surface effect vehicles, missiles, space probes, and related systems.

Job Duties:

1. Establishes computational methods, and computer input data for analyzing problems.
2. Analyzes designs and develops configurations to insure satisfactory static and dynamic stability and control characteristics for completed vehicle.
3. Initiates and assists in formulating and evaluating laboratory, flight, and wind tunnel test programs, and prepares reports and conclusions for other engineering and design personnel.
4. Coordinates activities of model design group and model shop to assure required configuration of wind tunnel models.
5. Prepares air load data on vehicle to conform to aerodynamic requirements.

JOB TITLE: Stress Analyst

D.O.T. No.: 002 061 030

Major Job Function:

Conducts stress analyses on designs of experimental, prototype, or production aircraft, space vehicles, surface effect vehicles missiles, and related components to evaluate ability to withstand stresses imposed during flight or ground operations.

JS AT 1

JS AT 2

Stress Analyst Job Duties:

1. Analyzes ability of structural components to withstand stresses imposed by load, speed, temperature, performance requirements, and ground tests.
2. Studies preliminary specifications and design requirements to determine strength and bending characteristics of parts, assemblies, and total air frame.
3. Consults with design personnel regarding results of, and need for, additional analysis, testing, or design modifications.

JOB TITLE: Research Mechanic

D.O.T. No.: 002 280 010

Major Job Function:

Sets up and operates equipment to test metal aircraft structural, hydraulic, and pneumatic parts, assemblies, and mechanisms, according to standard procedures, to discover faults of design and fabrication.

Job Duties:

1. Installs units, such as rib assemblies, struts, landing gears, valves, ducts, universal joints, gears, and motors, in testing equipment and machines, and connects wiring, tubing, couplings, and power sources, using handtools.
2. Operates test equipment and machines to determine factors, such as stress, strain, pressures, turbulences, velocities, flow of fuel, oil and air, wear, and usability of installed units, under conditions of heat, cold, high speeds, torque, and load.
3. Measures induced variations from normal with precision instruments, such as micrometers, verniers, calipers, manometers, pressure gauges, flowmeters, strain gauges, and dynamometers, and records results for analysis by Engineering Department.

JOB TITLE: Aeronautical Engineer

D.O.T. No.: 022 061 014

Major Job Function:

Designs, develops, and tests aircraft, space vehicles, surface effect vehicles, and missiles, applying engineering principles and techniques.

Job Duties:

1. Designs and develops commercial, military, executive, general aviation or special purpose aircraft; space vehicles, satellites, missiles, scientific probes; or other related hardware or systems.
2. Test models, prototypes, subassemblies, or production vehicles to study and evaluate operational characteristics and effects of stress imposed during actual or simulated flight conditions.

JOB TITLE: Passenger Service Manager

D.O.T. No.: 189 167 082

Major Job Function:

Directs and coordinates airline station activities at transport station or terminal point located at airport to provide services for scheduled flight operations.

Job Duties:

1. Reviews station activity reports to ascertain data required for planning station operations.
2. Directs preparation of work schedules to obtain optimum utilization of manpower and facilities.
3. Coordinates activities of passenger reservations and ticketing, passenger services, ramp and cargo services, commissary services, and dispatching of aircraft to insure operations meet company and government policies and regulations.
4. Directs preparation of passenger lists, cargo manifests, and plans for storage of cargo and baggage aboard aircraft.
5. Evaluates training and performance records of employees to determine and formulate training designed to increase employee efficiency.

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JOB TITLE: Chief Pilot

D.O.T. No.: 196 167 010

Major Job Function:

Directs operation of flight department of airline.

Job Duties:

1. Conducts indoctrination training for new pilots and refresher training for experienced pilots.
2. Reviews reports on pilot performance and forwards reports to Federal Aviation Administration.
3. Discusses operational and personal problems with subordinates to improve moral and efficiency.
4. Studies technical manuals of airplane and equipment manufacturers and government regulations affecting flight operations to insure that company training manuals adhere to legal requirements and are adapted to type of aircraft in use.
5. Represents company in advisory capacity during contract negotiations with pilots' union.
6. Accompanies flights to observe performances of pilots.
7. Conducts training classes for flight personnel covering emergency procedures and use of survival equipment.
8. Directs preparation of flight-crew schedules and assignment of personnel.

JOB TITLE: Navigator

D.O.T. No.: 196 167 014

Major Job Function:

Locates position and directs course of airplane on international flights, using navigational aids, such as charts, maps, sextant, and slide rule.

Job Duties:

1. Establishes position of airplane by use of navigation instruments and charts, celestial observation, or dead reckoning.

Navigator Job Duties (continued):

2. Directs deviations from course required by weather conditions such as wind drifts and forecasted atmospheric changes.
3. Utilizes navigation aids, such as radio beams and beacons, when available.
4. Keeps log of flight.
5. Must be licensed by Federal Aviation Administration.

JOB TITLE: Airline Pilot

D.O.T. No.: 196 263 014

Major Job Function:

Pilots airplane to transport passengers, mail, or freight, or for other commercial purposes.

Job Duties:

1. Reviews ship's papers to ascertain factors, such as load weight, fuel supply, weather conditions, and flight route and schedule.
2. Orders changes in fuel supply, load, route, or schedule to insure safety of flight.
3. Reads gauges to verify that oil, hydraulic fluid, fuel quantities, and cabin pressure are at prescribed levels prior to starting engines.
4. Starts engines and taxis airplane to runway.
5. Sets brakes, and accelerates engines to verify operational readiness of components, such as superchargers, carburetor-heaters, and controls.
6. Contacts control tower by radio to obtain takeoff clearance and instructions.
7. Release brakes and moves throttles and hand and foot controls to take off and control airplane in flight.
8. Pilots airplane to destination adhering to flight plan and regulations and procedures to Federal Government, company, and airport.

JS AT 6

Airline Pilot Job Duties (continued):

9. Logs information, such as time in flight, altitude flown, and fuel consumed.
10. Must hold Commercial Pilot's Certificate issued by Federal Aviation Administration.

JOB TITLE: Test Pilot

D.O.T. No.: 196 263 042

Major Job Function:

Pilots new, prototype, experimental, modified, and production aircraft to determine their airworthiness.

Job Duties:

1. Inspects aircraft prior to flight by examining items, such as quantity of fuel and operation of controls.
2. Starts and warms engine, listens to engine sounds at various speeds, and monitors instruments to detect malfunctions.
3. Taxies aircraft to test controls, brakes, and shock absorbers.
4. Radios control tower for takeoff instructions, releases brakes, and moves throttles and hand and foot controls, to take off and control aircraft in flight.
5. Puts aircraft through maneuvers, such as stalls, dives, glides, rolls, turns, and speed runs, to test and evaluate stability, control characteristics, and aerodynamic design.
6. Observes recording and operating instruments during test to evaluate airplane performance.

JOB TITLE: Aircraft-Equipment-and-Accessories Assembler D.O.T. No.: 222 587 010

Major Job Function:

Packs airplane equipment and accessories for shipment with completed airplanes, according to equipment checksheets and blueprint specifications.

Aircraft-Equipment-and-Accessories Assembler Job Duties:

1. Compares serial or part numbers of installed subassemblies, accessories, and equipment with numbers listed on blueprint and company specifications.
2. Requests replacement of damaged or missing parts.
3. Locates and identifies equipment and accessories to be shipped with airplane, such as oxygen bottles and masks, parachutes, life rafts, and signal flares.
4. Routes accessories to inspection department for approval.
5. Packs, crates, and labels approved accessories for shipment.
6. Prepares lists of equipment and accessories.

JOB TITLE: Reservations Agent

D.O.T. No.: 238 367 018

Major Job Function:

Makes and confirms reservations for passengers on scheduled airline flights.

Job Duties:

1. Arranges reservations and routing for passengers at request of ticket agent or customer, using timetables, airline manuals, reference guides, and tariff book.
2. Types requested flight number on keyboard of on-line computer reservation system and scans screen to determine space availability.
3. Telephones customer or ticket agent to advise of changes in flight plan or to cancel or confirm reservation.

JOB TITLE: Traffic Agent

D.O.T. No.: 252 257 010

Major Job Function:

Solicits freight business from industrial and commercial firms and passenger-travel business from travel agencies, schools, clubs, and other organizations.

JS AT 8

Traffic Agent Job Duties:

1. Calls on prospective shippers to explain advantages of using company facilities.
2. Quotes tariffs, rates, and schedules.
3. Explains available routes, load limits, and special equipment available, and offers suggestions in methods of loading, crating, and handling freight.
4. Calls on travel agents, schools, clubs, and other organizations to explain available accommodations offered by company.
5. Quotes fares, schedules, and available itineraries offered to groups by company.
6. Speaks to members of groups and organizations and exhibits travel movies showing points of interest along routes to stimulate interest in travel.
7. Distributes descriptive pamphlets.
8. Acts as liaison between shipper and carrier to obtain information for settling complaints.

JOB TITLE: Propeller Lay-Out Worker

D.O.T. No.: 600 381 010

Major Job Function:

Lays out centerlines on propeller blades forgings.

Job Duties:

1. Positions and blocks blade to specified angle on bench, using protractor.
2. Sets metal template in centerline cut in bench and positions blade on template, using square.
3. Inscribes horizontal lines at specified interval and temporary vertical line on blade, using surface gauge.
4. Measures width and thickness of blade at intersection of vertical and horizontal lines, using calipers.
5. Clamps blade in vise and bends blade with special lever to correct imbalance of metal around these points.

Propeller Lay-Out Worker Job Duties (continued):

6. Marks finish centerline on blade, using surface gauge.
7. Drills hole at specified point in tip of blade, using powered hand drill.

JOB TITLE: Airframe-and-Power-Plant Mechanic D.O.T. No.: 621 281 014

Major Job Function:

Services, repairs, and overhauls aircraft and aircraft engines to insure airworthiness.

Job Duties:

1. Repairs, replaces, and assembles parts, such as wings, fuselage, tail assembly, landing gear, control cables, propeller assembly, and fuel and oil tanks, using tools, such as power shears, sheet metal breaker, arc and acetylene welding equipment, rivet gun, and air or electric drills to rebuild or replace airframe or its components.
2. Consults manufacturers' manuals and airline's maintenance manual for specifications and to determine feasibility of repair or replacement according to malfunction.
3. Examines engines for cracked cylinders and oil leaks and listens to detect sounds of malfunctioning, such as sncking or burnt valves.
4. Inspects turbine blades to detect cracks or breaks.
5. Tests engine operation, using testing equipment, such as ignition analyzer, compression checker, distributor timer, and ammeter to locate source of malfunction.
6. Replaces or repairs worn or damaged components, such as carburetors, superchargers, and magnetos, using handtools, gauges and testing equipment.
7. Removes engine from aircraft, using hoist or forklift truck.
8. Disassembles and inspects parts for wear, warping, or other defects.

JS AT 10

Airframe-and-Power-Plant Mechanic Job Duties (continued):

9. Repairs or replaces defective engine parts and reassembles and installs engine in aircraft.
10. Adjusts and repairs electrical wiring system and aircraft accessories and instruments.
11. Inspects, services, and repairs pneumatic and hydraulic systems.
12. Performs miscellaneous duties to service aircraft, including flushing crankcase, cleaning screens, greasing moving parts, and checking brakes.

JOB TITLE: Rib Builder

D.O.T. No.: 769 281 010

Major Job Function:

Fabricates and assembles wooden airplane and glider parts to form major units, such as spars, wings, fins, and fuselage sections, following blueprints and written specifications and using hand tools, power tools, and measuring instruments.

Job Duties:

1. Lays out design and cuts and shapes parts, using power tools, such as saw, planer, shaper, and router.
2. Trims parts to fit and smooths edges of cut pieces, using files, rasps, plane, scraper, and sanding machine.
3. Positions parts in jigs and verifies assembly dimensions, using scales, templates, gauges, straightedge, and square.
4. Fastens parts together and installs reinforcement members, such as stiffeners, gussets, stays, braces, or clips, using glue, nails, screws, and bolts.
5. Glues wooden skin to framework and sands surface to smooth finish.

JOB TITLE: Rocket Engine Tester

D.O.T. No.: 806 261 022

Major Job Function:

Test fires rocket engine and interprets test data to determine performance characteristics, using testing instruments, mathematical formulas, and calculating instruments.

Job Duties:

1. Positions or directs other workers to position engine on test stand, using power hoist.
2. Attaches fuel lines, instruments, controls, and accessories to engine, using handtools.
3. Attaches testing instruments, such as dynamometers and manometers, to engine.
4. Turns engine controls to start and operate engine at varying speeds for specified periods of time.
5. Records test data from instruments, such as engine speed and temperature, content of exhaust emissions, and fuel consumption.
6. Calculates engine performance, using test data, standardized formulas, and sliderule.
7. Prepares test report and approves or rejects engine according to test results.

JOB TITLE: Subassembly Inspector

D.O.T. No.: 806 281 022

Major Job Function:

Inspects assemblies, such as wings, body sections, flap, bonded structure, and tail assemblies, joining of subassemblies into major structures, and complete aircraft for adherence to sequence of operation and for correctness of assembly, according to blueprints, drawings, and production and inspection manuals.

JS AT 12

Subassembly Inspector Job Duties:

1. Examines cables for kinks, cracks, and loose connections.
2. Inspects alignment of parts, using templates, check jigs, and sight levels.
3. Verifies location, size, shape, reaming, and countersinking of bolt and rivet holes, using ball gauges, templates and calipers.
4. Inspects assembly of mechanical equipment, such as landing gear struts and wing flap and rudder actuators, for tolerance of fit, using micrometers, calipers, and verniers.
5. Examines installation of engines, mechanical equipment, plumbing lines and tanks, wiring shields, and brackets in subassemblies and aircraft structures to verify location and fastening and to determine surface defects, such as scratches and cracks.
6. Examines fit and seal of windows and doors and installation of bulkheads, seats, instrument panels, and decorative panels.
7. Examines installation of floor and wall coverings and upholstery to verify color, quality, and fit of material.
8. Writes inspection reports.

JOB TITLE: Plumbing Systems Tester

D.O.T. No.: 806 281 054

Major Job Function:

Tests plumbing systems installed in aircraft for conformance to specifications, following manuals and blueprints and using test equipment and handtools.

Job Duties:

1. Examines oil, fuel, hydraulic, and oxygen lines and heating systems to detect loose fittings and dented or bent tubing.
2. Connects systems to test equipment, such as flowmeter, pressure gauge, and pumps, using fittings and wrenches.
3. Fills tanks and lines with oxygen, liquids, or gases, using hand pump or compressor machine.

Plumbing Systems Tester Job Duties (continued):

4. Adjusts and regulates valves, drains, and locks, and observes dial readings to detect leakage and to measure flow of air and liquids.
5. Closes and locks doors, windows, and hatches of pressurized cabin to verify fit and locking devices.
6. Stamps approval on accepted parts and returns defective units for rework.

JOB TITLE: Skin Fitter

D.O.T. No.: 806 381 054

Major Job Function:

Fits sheet metal coverings to fuselage bulkheads and other sections of aircraft and fastens sheet metal in position preparatory to welding or riveting, using hand tools and metal fabricating machinery.

Job Duties:

1. Trims edges of preformed sheet to insure flush fit, using rasp.
2. Drills rivet holes through sheets and flanges of bulkheads, using electric drill.
3. Cuts, bends, and trims sheet metal airfoil parts to shape, using metal-fabricating machinery and handtools.
4. Fits sheet metal parts to aircraft framework, using self-tapping screws or C-Clamps.
5. Cuts away damaged areas of skin, using metal snips and attaches patch flush with adjoining skin, using rivet gun.

JOB TITLE: Subassembly Assembler

D.O.T. No.: 806 484 010

Major Job Function:

Assembles parts, such as spars, ribs, and braces, to form structural subassemblies, such as air foils, rudders, flaps, stabilizers, elevators ailerons, fins, fuselage tops and bulk heads, doorframes, doors, and windows, according to specifications, using handtools and portable power tools.

Subassembly Assembler Job Duties:

1. Aligns parts on jigs, using templates and fixtures, or by measuring from blueprint index points and station lines with rule, protractor, and divider.
2. Files, saws, and deburrs parts, using handtools or portable power tools.
3. Measures parts with micrometers and calipers to verify dimensions.
4. Clamps parts together and drills, reams, and countersinks holes, using power hand drill.
5. Assembles parts and fittings, such as braces, hinges, brackets, keyways, and nut plates, using wrenches.
6. Deburrs keyways, holes, and cable grooves, using burring tool.
7. Marks color symbols on work as guide for riveting.
8. Cements rubber or felt weather stripping to metal doors, glass and plastic windows, and assemblies.

JOB TITLE: Pressure Sealer-and-Tester

D.O.T. No.: 806 684 110

Major Job Function:

Cleans, seals, and tests aircraft pressurized sections and cavities, according to specifications, using cleaning solvent, caulking gun, sealing compounds, and pressure testing equipment.

Job Duties:

1. Applies cleaning solvent to interior and exterior surfaces of compartments, such as fuel and water tanks, fuel vent systems, cabins, and cockpits, preparatory to sealing, using brush and rag waste.
2. Applies sealing compounds to surfaces, using hand sealing tool or pressure gun.
3. Dries sealant, using heat lamps and compressed hot air.
4. Bolts access doors and hatches, disconnects plumbing lines, electrical cable and rigging, and caps connections with plugs and threaded fixtures to make section airtight.

Pressure Sealer-and-Tester Job Duties (continued):

5. Connects airhoses of pressure-testing equipment to sealed section, using wrench.
6. Turns valves to admit air pressure and observes air pressure gauges to determine leakage.
7. Brushes soapy solution on seams and rivets of section to locate leaks indicated by air bubbles.
8. Applies sealing compound to leaks.
9. Reinstalls plumbing and electrical and rigging connections.

JOB TITLE: Cable Stretcher and Tester

D.O.T. No.: 806 685 010

Major Job Function:

Tends cable-stretching machine that stretches aircraft control cables to specified length and tests holding capacity of terminal fittings.

Job Duties:

1. Inserts pins through cable terminal fittings and attaches cable ends to stretching machine fixtures.
2. Slides movable fixture along track on machine bed to take up slack in cable and bolts fixture in place.
3. Sets regulator dial at specified tension reading according to length and thickness of cable.
4. Starts machine that stretches cable to specified length and tests holding capacity of terminal fittings.
5. Examines cables to detect loosened fittings or broken strands.

JOB TITLE: Avionics Technician

D.O.T. No.: 823 281 010

Major Job Function:

Inspects, tests, adjusts, and repairs aircraft communication, navigation, and flight control systems.

Avionics Technician Job Duties:

1. Tests and replaces defective instruments, such as microphones, headsets, dopplers, selcall, trancelvers, transponders, and autopilots, using electricians tools, circuit analyzers, oclloscopes, and other testing devices.
2. Calibrates installed or repaired equipment to prescribed specifications.
3. Signs overhaul documents for equipment replaced or repaired.
4. Adjusts frequencies of radio sets by signaling ground station and turning setscrews.
5. Required to hold radiotelephone license issued by Federal Communications Commission or Federal Aviation Agency.

JOB TITLE: Airplane Electrician

D.O.T. No.: 825 281 018

Major Job Function:

Installs, adjusts, and maintains electrical wiring, switches, and fixtures in airplanes.

Job Duties:

1. Cuts insulated wire to length and installs in conduits attached to aircraft structure, in accordance with specifications.
2. Connects and solders wires to terminals and electrical components, following wiring diagrams.
3. Installs and wires wing-tip lights, taillights, interior light fittings, and dashlights.
4. Tests electrical equipment and instruments, using testing equipment, such as ohmmeter, ammeter, oscilloscope, and signal generator, and makes adjustments as necessary.
5. Diagnoses malfunctioning of equipment and repairs or replaces defective parts.
6. Modifies equipment in accordance with blueprint specifications and engineering drawings.

JOB TITLE: Wind-Tunnel Mechanic

D.O.T. No.: 827 381 014

Major Job Function:

Installs and repairs mechanical and electrical equipment in wind tunnel used to test aircraft, following specifications and using handtools, metalworking machines, and measuring instruments.

Job Duties:

1. Installs mechanical equipment, such as air-pressure ducts, wind producing motors, and fans, using handtools.
2. Operates power machines, such as lathes, saws, and grinders, to repair or rebuild equipment.
3. Installs electrical equipment and circuits.

JOB TITLE: Load-Test Mechanic

D.O.T. No.: 929 382 010

Major Job Function:

Operates hydraulic proof-loading equipment to load-test material handling fixtures, such as cables, steel slings, and tie rods.

Job Duties:

1. Reads specifications to determine load-test procedures.
2. Fastens fixture to load-testing equipment, using work aids, such as clamps, suspension bars, and spreader bars.
3. Positions testing equipment on hydraulic test stand and connects hydraulic lines.
4. Turns controls of hydraulic load-test equipment to apply weight stress and records maximum load at which lifting gear or fixture fatigues or breaks.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

Instructional Section:

LAND TRANSPORTATION

Title of Unit:

INTRODUCTION TO LAND TRANSPORTATION

DESCRIPTION OF UNIT

This unit includes an overview of the many types of land transportation and the ways transportation affects our daily lives.

UNIT OBJECTIVE

After completion of this unit the student will be able to:

1. List the three major types of land transportation and;
2. Explain the importance of land transportation.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. List the three major types of land transportation;
2. List the systems of land transportation used to carry 3 necessary, common items to the consumer;
3. List the systems of land transportation involved in 3 jobs;
4. Correctly match definitions to key words used in this unit.

OUTLINE OF CONTENT

- I. What land transportation is: carrying goods and people over land
- II. Three systems for carrying materials over land
 - A. Highways--A roadway designed for motor vehicle transportation.
 - B. Railroads--A system of tracks for carrying trains whose wheels are designed for the tracks.
 - C. Pipelines--A direct enclosed channel that provides a continuous flow of liquid or gaseous material.
- III. Two systems for carrying people over land
 - A. Highways--Automobiles, trucks, vans, buses, etc.
 - B. Railroads--Passenger trains, subways, monorails, etc.
- IV. Types of Highways
 - A. Urban streets--City streets, avenues, boulevards, etc.
 - B. Highways--Primary highways and secondary highways.
 - C. Interstate highways--Federal highway system connecting larger U. S. cities.
 - D. Rural roads--Paved and unpaved county roads.
- V. Types of vehicles used on highways
 - A. Cars
 - B. Buses
 - C. Motorcycle
 - D. Bicycles
 - E. Trucks
 - F. Recreational vehicles (campers, trailers, etc.)
 - G. Farm vehicles
- VI. Types of railroad transportation
 - A. Passenger trains
 - B. Freight trains
- VII. Other types of Conveyances
 - A. Pipelines
 - 1. Liquids
 - 2. gas
 - B. Industrial Conveyances
 - 1. Assembly lines
 - 2. Conveyor belts
 - C. People Conveyances
 - 1. elevators
 - 2. escalators
 - 3. wheel chairs
 - 4. recreational conveyances
- VIII. Land transportation involved in all the products we use.
- IX. Land transportation involved in many jobs,

TEACHER ACTIVITIES

1. Provide students with instructional module.
2. Discuss unit and performance objectives.
3. Show Transparency #1. Discuss types of land transportation, vehicles used, people versus material transportation.
4. Go over information sheet.
5. Discuss the future of transportation.
6. Present Transparency #2. Have students identify the used of pipelines, urban roads, highways, railroads, industrial conveyance and people conveyance.
7. Assign Activity #1. Do with class or assign for them to think through on their own.
8. Complete Activity #2.
9. Discuss the fact that many jobs and occupations are involved in the various kinds of land transportation. Do Activity #3 and discuss answers.
10. Give test and evaluate results.

LT 1.4

STUDENT ACTIVITIES

1. Read objectives.
2. Study Information Sheets.
3. Complete Activity Sheets.
4. Take test.

REFERENCES/RESOURCES

1. Books

Reis, Etta Schneider, Transportation in the World Today, Creative Educational Society Mankato, MN, 1965.

2. Information Sheets

3. Transparency masters.

A. Terms and Definitions

1. Transport--To carry goods or people from one place to another.
2. Transportation--The act or process of carrying goods or people from one place to another.
3. Land Transportation--The movement of people or goods over land.
4. Urban--In the city.
5. Rural--In the country.
6. Convey--To carry
7. Conveyance--A thing which carries people or goods like a car, a wagon, etc.
8. Vehicle--A thing which carries people or goods.
9. Highway--A road designed for motor vehicles.
10. Railroad--A system of tracks used to carry trains with wheels designed to fit the tracks.
11. Pipeline--A direct, enclosed channel that provides a continuous flow of liquid or gas materials.
12. Recreational vehicle--A vehicle used mainly for recreation. These vehicles include campers, trailers, camping vans, etc.

I. Transportation Systems

- A. There are three (3) systems for carrying goods over land:
 - 1. Highways--transportation of goods by truck, automobile, etc.
 - 2. Railroads--transportation of goods by railroad freight cars.
 - 3. Pipelines--transportation of liquids and gases.
- B. There are two (2) systems for carrying people over land:
 - 1. Highways--transportation of people by car, bus, truck, van, recreational vehicles.
 - 2. Railroad--transportation of people by passenger trains, subways, monorails, etc.

II. Types of Highways

- A. Urban streets--city transportation over streets, avenues, boulevards, freeways, etc.
- B. Highways--primary, secondary and Interstate.
- C. Rural roads--paved and unpaved county roads.

III. Types of railroad transportation

- A. Passenger trains--any train used for the transportation of people.
- B. Freight trains--a train used for the transportation of freight.

IV. Pipelines--The third most common type of transportation system.

- A. Liquid pipelines--transports liquid material such as oil, oil products, and water.
- B. Gas pipelines--transports gaseous material such as natural gas and steam.

V. Other Conveyances

- A. Industrial Conveyances
 - 1. Assembly lines--moving hooks and belts located in factories that carry parts to be assembled from one part of the factory to another.
 - 2. Conveyor belts--moving belts that transport goods from one point to another.
- B. People conveyances
 - 1. Elevators--enclosed compartments that move people between floors in buildings by use of cables and pulleys.
 - 2. Escalators--moving staircases that carry people from one floor to another.
 - 3. Wheel chairs--for transporting people who are unable to walk.
 - 4. Recreational conveyances--such as amusement park rides, ski lifts, cable cars, etc.
 - 5. Animals--horseback, donkeys, burros, etc.

- I. Transportation in other countries--In more primitive societies and in areas where highways are less developed, people still rely on animals for major forms of transportation. Horseback and camel riding are still major types of people transportation in some countries. Even in the U. S. horses are important on farms and ranches. In many areas of the world, people still hitch wagons to horses, mules, and donkeys to carry freight. As countries become more industrialized, the systems of transportation must be improved to carry more freight at faster rates of speed.
- II. The future of transportation--What will transportation in the year 2000 be like?

Scientists predict that by the year 2000 most of the world's oil supply will be gone. Since most of our modern vehicles use gasoline or some other oil based fuel, there is great concern over how we will transport people and goods in the 21st century. As you study land transportaton, consider what types of transportation will still be available if there are no supplies of oil.

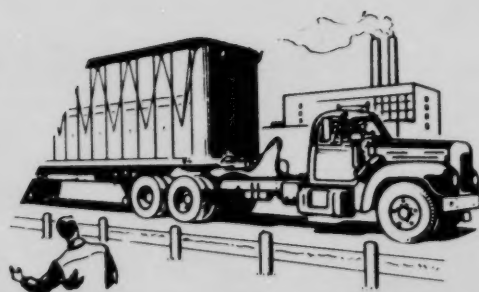
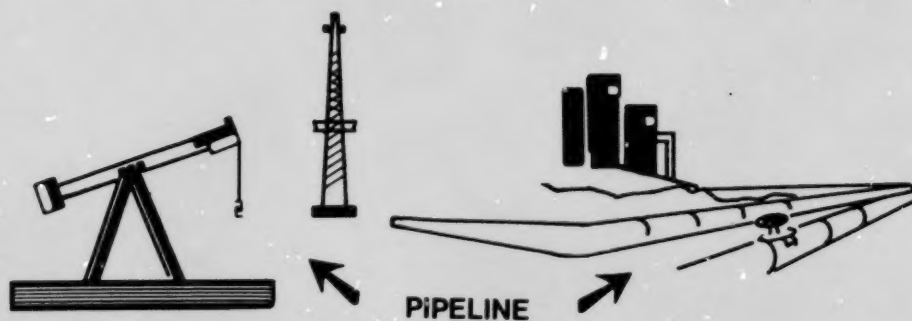
POPULATION MOBILITY



399

400

TYPES of LAND TRANSPORTATION



TRUCK

Student Activity #1

General Instructions: On a sheet of paper answer each of the following questions.

1. A farmer has harvested his corn. He has 4000 ears of corn to sell. He lives about 50 miles away from Memphis. He wants to bring the corn to a market in Memphis. What 3 kinds of roads or highways would he travel on? What kind of vehicle would he probably use?
2. Sam wants to visit California. He lives in Memphis. Name 4 vehicles he might use to get to California. For each vehicle tell what transportation system is involved. Example - a car would be one kind of vehicle. It would be used in the highway transportation system.
3. An H. I. S. factory owner has produced 500 western shirts to sell. The factory is in Tennessee. The 5 stores which will sell these shirts are in Dallas, Texas. What two systems of transportation could the factory owner use to get the products to the distribution centers in each city? Then what systems could the owner use to get the shirts to the right stores? What vehicles would be used in each system?
4. Inside a Coca Cola factory the bottles are filled by a machine. Then the bottles have to be capped. What kind of industrial conveyance will be used to get the filled bottles to the capping machine?
5. A class of high school seniors plan to go together to Florida. How could they get there from Memphis in a way that would keep the whole group together. Name two kinds of transportation.

SUGGESTED ANSWERS for STUDENT ACTIVITY #1

1. rural roads, highways, urban streets
probably a pick up truck
2. bus, motorcycle, truck, car, bicycle on highways
a train on the railways
3. highways or railroads to get the shirts to the distributor and
highways to get the shirts from the distributor to the stores.
trucks on highways, trains or railroads
4. conveyor belt
5. by bus or highway or by train

Student Activity #2

A list of types of transportation is given at the left. From this list select the types of transportation that would be used to get each of the following necessary items into a customer's hands.

- | | |
|----------------|-----------------|
| Highways | 1. Milk |
| Pipelines | a. |
| Railroads | b. |
| Conveyor belts | c. |
| Assembly lines | d. |
| Rural roads | 2. Gasoline |
| Urban streets | a. |
| | b. |
| | c. |
| | d. |
| | e. |
| | 3. Hershey bars |
| | a. |
| | b. |
| | c. |
| | d. |
| | e. |
| | f. |
| | 4. Televisions |
| | a. |
| | b. |
| | c. |
| | d. |
| | e. |
| | f. |
| | 5. Water |
| | a. |

SUGGESTED ANSWERS for ACTIVITY #2

1. rural roads
highways
railroads
conveyor belts
urban streets
2. pipelines
highways
urban streets
rural roads
3. conveyor belts
highways
urban streets
railroads
rural roads
4. assembly lines
conveyor belts
railroads
highways
urban roads
rural roads
5. pipelines

Student Activity #3

The three main systems of land transportation are highway, railroad, or pipeline. Tell which system is involved in the occupations below. May have more than one system. (Do not consider how the person gets to and from work.)

- | | |
|------------------------------|----------------------------|
| 1. Taxi driver | 6. Designer of automobiles |
| 2. Service station attendant | 7. Construction worker |
| 3. Traveling salesman | 8. Trucker |
| 4. Bus driver | 9. Railroad conductor |
| 5. Engine mechanic | |

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SUGGESTED ANSWERS for ACTIVITY #3

1. Highways
2. Highways
3. Highways
4. Highways
5. Highways, railroads
6. Highways
7. Highways, railroads, pipeline
8. Highways
9. Highways, railroads, pipeline
10. Railroads

SUGGESTED TEST

1. List three major types of land transportation.
 - a.
 - b.
 - c.

2. Which systems of land transportation are used in getting the following products to the customer?
 - a. furniture _____
 - b. gasoline _____
 - c. cars _____

3. Which systems of land transportation are involved in the following jobs?
 - a. engine mechanics _____
 - b. construction workers _____
 - c. bus drivers _____

4. A list of definitions is given on the right. In the blank to the

_____ 1. transport	a. in the country
_____ 2. transportation	b. a thing which carries people or things
_____ 3. land transportation	c. to carry goods or materials
_____ 4. urban	d. in the city
_____ 5. rural	e. the act or process of carrying goods or materials
_____ 6. conveyance	f. carrying goods or materials over land
_____ 7. vehicle	g. a thing which carries people or things

TEST ANSWERS

1. Highways, railroad, pipeline
2. A. Highway, railroad
B. pipeline, highway, railroad
C. Railroad, highways
3. A. Highway, railroads
B. Highway, railroad, pipeline
C. Highway
4. c 1.
 e 2.
 f 3.
 d 4.
 a 5.
 b 6.
 g 7.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

LAND TRANSPORTATION

Title of Unit:

ECONOMIC IMPORTANCE OF LAND TRANSPORTATION

DISCRIPTION OF UNIT

This unit contains a brief overview of the use and economic importance of the various land transportation systems within the United States.

UNIT OBJECTIVE

After completion of this unit the student will be familiar with land transportation systems within the United States and how these transportation systems effect our economy.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. List at least five (5) items that people need that require a reliable system of land transportation;
2. List at least three (3) industrial needs of land transportation;
3. Match items of necessity with their functions in our economy;
4. Correctly answer 75% of the questions over this material;

OUTLINE OF CONTENT

- I. People depend upon transportation for
 - A. Food
 - B. Water
 - C. Clothing
 - D. Fuels
 - E. Building Materials
 - F. Other finished products
- II. Industry depends upon land transportation systems for I
 - A. Raw materials
 - B. Movement of materials within the factory
 - C. Delivery of finished products to market
 - D. Transportation of employees to and from work
 - 1. Private auto
 - 2. Mass transportation
- III. Businesses depend upon land transportation systems for: II
 - A. Bringing products to market
 - B. Bringing consumers to market
 - C. Delivery of products to consumers
 - D. Transportation of employees to and from work
 - E. Transportation of employees in work related functions (Salespeople, buyers, bus drivers, etc.)
- IV. Economic problems of the 1970's and 1980's related to transportation I
 - A. Fuel supplies less available and more expensive
 - people drive less
 - car and truck sales go down
 - car manufactures cut back on production and lay off workers
 - B. Related industries slow down
 - metal mining
 - steel manufacuting
 - rubber industry
 - trucking industry, etc.
 - C. Prices on all transported goods go up due to high fuel prices
 - people buy less goods
 - most businesses slow down
 - results in high unemployment

TEACHER ACTIVITIES

1. Provide students with instructional module.
2. Discuss unit and performance objectives.
3. Engage students in a discussion of how land transportation is involved in different items that they can see in the classroom.

Note: Everything the student sees will in some way be affected by some means of land transportation.
4. Discuss how life might be without modern means of land transportation.
5. Discuss the content and student information sheets:
 - show T. M. #1 to illustrate how products are transported from raw material stage to industry to market;
 - have student tell how other means of transportation might be involved.
6. Discuss how businesses and industries rely upon some means of land transportation to transport employees to and from work.
7. Have students name various means of current transportation. 8 advantages and disadvantages of each.
8. Discuss current economic problems and how they relate to problems in transportation.
9. Have students complete activity sheets and discuss answers.
10. Give test and evaluate results.

STUDENT ACTIVITIES

1. Read objectives.
2. Study information sheets.
3. Participate in class discussion.
4. Complete activity sheet.
5. Take test.

REFERENCES/RESOURCES

References

1. Fair, Marvin, L. and Williams, Ernest W., Economics of Transportation, Harper Brothers, New York, 1959.

Resources

1. Information Sheets.
2. Transparencies.

I. People Needs

A. Food supplies transported by

1. Farm implements
2. Trucks
3. Railroads
4. Conveyances
5. Private Auto

B. Water transported by pipelines

C. Clothing transported by

1. Trucks
2. Farm Implements (for raw materials such as cotton and wool)
3. Railroads
4. Conveyances

D. Fuels transported by

1. Pipelines
2. Trucks
3. Railroads
4. Conveyances

E. Building Materials transported by

1. Trucks
2. Railroads
3. Conveyances

F. Other finished products

II. Industrial Needs

A. Transportation of raw materials to factories

B. Rapid movement of materials and products within the factories

C. Delivery of finished products to market

D. Transportation of employees to and from work

1. Private Auto
2. Mass Transportation

III. Business Needs

A. Transportation of products to markets

B. Transportation of consumers to markets

C. Transportation of products to consumers

D. Transportation of employees to and from work

E. Transportation of employees in job related functions such as salespeople, buyers, bus drivers, etc.

IV. Economic problems of the 1970's and 1980's related to transportation

- A. Fuel supplies less available and more expensive - People drive less - Car and truck sales go down - Car manufactures cut back on production and lay off workers

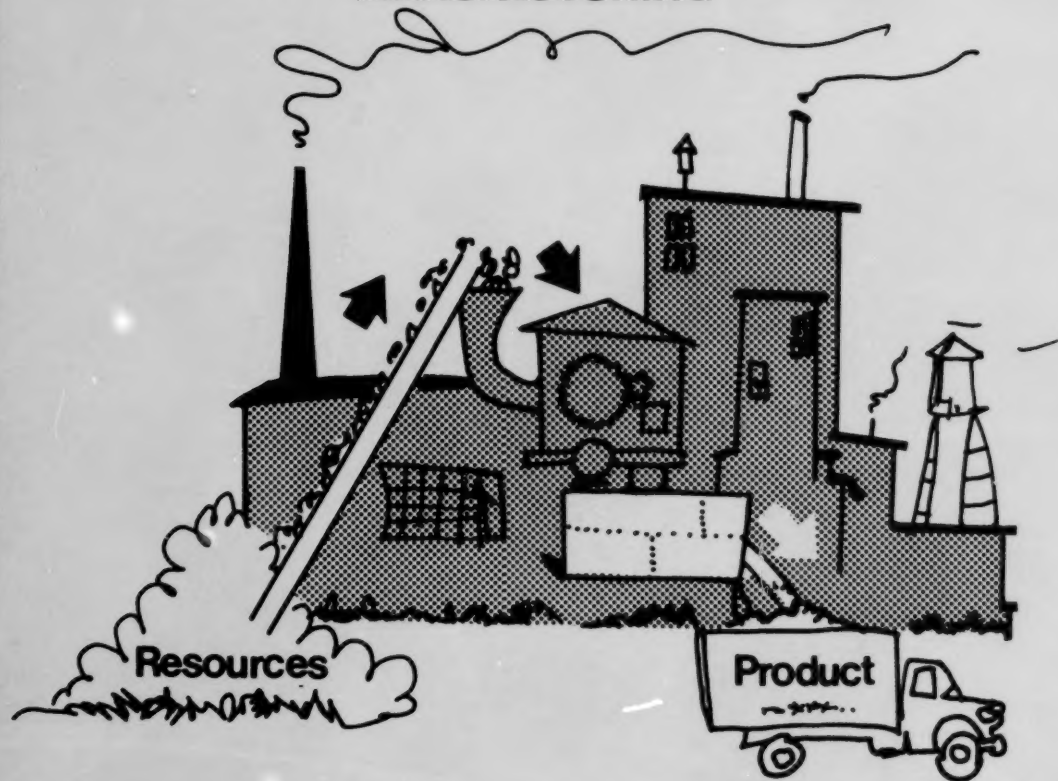
B. Related Industries slow down

- metal mining
- steel manufacturing
- rubber industry
- trucking industry
- resorts and vacation areas, etc.

C. Prices on all transported goods go up due to high fuel prices

- People buy less goods
- Most businesses slow down
- Results in high unemployment

MANUFACTURING



Student Activity #1

- A. Write a short paper explaining how you would transport a shipment of oil from the oil fields in Alaska to a gasoline refinery in Southern California. Then explain how you would ship the refined gasoline to a service station in Memphis, Tennessee. Be sure to show all the forms of transportation that you would use, and use the most economical means of transportation that you can think of.
- B. Write a short paper explaining how you would transport a shipment of trees from a forest outside Spokane, Washington to a sawmill in Spokane. Then explain how you would transport the finished lumber from the sawmill to a building supplier in Memphis, Tennessee and from the building supplier to a construction site in Memphis where a house is being built. Show all the forms of transportation and use the most economical means.

SUGGESTED ANSWERS TO ACTIVITY SHEET #1

A. Paper should include:

1. Pipeline from Alaska to Southern California
2. Railroad from Southern California to Memphis
3. Gasoline truck from railroad to service station

B. Paper should include:

1. Truck from forrest to sawmill
2. Railroad from sawmill to Memphis
3. Truck from railroad to building supplier
4. Delivery truck from building supplier to construction sight

Student Activity #2

- A. Go on a shopping trip to a grocery store with your parents. By filling in the chart below, determine how much it cost your parents to purchase the groceries and transport it to your house.

1. Date _____
2. Name of Store _____
3. Number of miles on your odometer when you return from the store _____
4. Number of miles on the odometer before you leave home _____
5. Number of miles driven (subtract #4 from #3) _____
6. Amount of miles per gallon that your car gets. (Ask your parents if you don't know) _____
7. Gallons of gasoline used (Divide #5 by #6) _____
8. Cost of gasoline per gallon (at your service station) \$ _____
9. Cost of gasoline that you used (multiply #8 by #7) \$ _____

- A. Mr. Jones, Mr. Smith, and Mr. Adams live next door to each other and they work at the same place of business. They each drive their own car 20 miles a day to get to and from work. They pay \$1.25 per gallon for gasoline. Mr. Jones' car gets 10 miles per gallon, Mr. Smith's car gets 20 miles per gallon, and Mr. Adams' car gets 25 miles per gallon. How much will each pay for gasoline each day to go to and from work? If each works five days a week, how much will each pay each week?

Mr. Jones \$_____ per day \$_____ per week

Mr. Smith \$_____ per day \$_____ per week

Mr. Adams \$_____ per day \$_____ per week

- B. Mr. Jones, Mr. Smith, and Mr. Adams decide to save money by carpooling each day. Because Mr. Adams' car gets better mileage, they decide to ride with Mr. Adams and share the gasoline cost evenly. How much money will each one pay each week? How much will each man save?

Mr. Jones will pay \$_____ per week and he will save _____ per week

Mr. Smith will pay \$_____ per week and he will save _____ per week

Mr. Adams will pay \$_____ per week and he will save _____ per week

SUGGESTED ANSWERS for ACTIVITY #3

A. Mr. Jones \$2.50 per day \$12.50 per week

Mr. Smith \$1.25 per day \$ 7.25 per week

Mr. Adams \$1.00 per day \$ 5.00 per week

B. Each will pay \$1.67 per week

Mr. Jones will save \$10.83 per week

Mr. Smith will save \$5.58 per week

Mr. Adams will save \$3.33 per week

- A. List five items that people need that require some means of land transportation. Give the means of land transportation that might be used for each item you list.

Item	Means of Transportation
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____

- B. List three necessities of industry that require some means of land transportation. Give one means of transportation for each.

Industrial Need	Means of Transportation
1. _____	_____
2. _____	_____
3. _____	_____

SUGGESTED TEST

1. Which means of commuter transportation is fast and convenient, but more expensive and wasteful of fuel?
A. Subway C. Private automobile
B. Bus D. Bicycle
2. Which means of transportation usually found in large cities is fast, economical and involves underground rail transportation?
A. Subway C. Bus
B. Trolley Car D. Freeways
3. Which type of conveyance is most often used to transport water to our cities?
A. Truck C. Railroad
B. Pipeline D. Conveyor belt
4. Which of the following fuel sources might use a conveyor belt as a means of transportation?
A. Kerosene C. Coal
B. Natural gas D. Oil
5. Which of the following means of transportation would be the cheapest way to transport fuel oil over a long distance?
A. Tanker truck C. Truck convey
B. Railroad tank car D. Pipeline
6. Listed below are items that require transportation. Beside each one indicate the means of land transportation which might have been used by placing one of the following letters in the space provided.
A. Truck D. Pipeline
B. Private automobile E. Conveyor belt
C. Freight train F. Bus

(Some may require more than one answer)

- | | |
|-------|--|
| _____ | 1) Logs from a forest to a sawmill |
| _____ | 2) Lumber from a sawmill to a building supply warehouse |
| _____ | 3) Lumber for a warehouse to a construction site |
| _____ | 4) Iron ore from iron mines to the steel mills |
| _____ | 5) Finished steel from one area of the steel mill to another area for shipping |
| _____ | 6) Natural gas from Louisiana to Tennessee |
| _____ | 7) Milk from the processor to the grocery store |
| _____ | 8) Large number of commuters from a suburban area to a business district |
| _____ | 9) Gasoline from a refinery to a service station |
| _____ | 10) Corn from a truck to the storage bins |

TEST ANSWERS

1. C

2. A

3. B

4. C

5. D

6. 1) A or B
2) A or B
3) A
4) A or B
5) E
6) D
7) A
8) F
9) A
10) E

SUPPLIES/EQUIPMENT

I. Supplies

1. Transparency Masters

II. Equipment

1. Overhead projector
2. Projection screen
3. Pointer

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section

LAND TRANSPORTATION

Title of Unit

HISTORY OF LAND TRANSPORTATION

DESCRIPTION OF UNIT

This unit provides a brief overview of the history of land transportation.

UNIT OBJECTIVE

After completion of this unit the student will be familiar with the important developments that led to modern U. S. land transportation.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Compare ten early forms of land transportation to their modern day counterparts;
2. Match eight historically related terms with their definitions.

OUTLINE OF CONTENT

- I. Early Man
 - A. Nomadic Tribes
 - 1. Moved from place to place to find food supplies
 - 2. Walked along animal trails
 - B. Civilized Man
 - 1. Settled in small communities
 - 2. Domesticated animals for use in farming and transportation about 6000 B. C.
 - 3. Invention of the wheel around 2700 B. C. was the first step toward modern transportation
 - 4. Built carts and primitive sleds pulled by man and domesticated animals.
 - 5. As travel between settlements increased, the trails became primitive roads
 - 6. New settlements were often built where two trails intersected.
 - 7. As transportation increased the need for better roads became more important
 - 8. Trade routes between settlements became established.
- II. U. S. Land Transportation
 - A. Colonial Transportation
 - 1. Early roads linked communities and cities
 - 2. Explorers moving west used Indian paths and animal trails
 - B. Settling the West
 - 1. Settlers in horse-drawn covered wagons began moving west
 - 2. Horse-drawn stage coaches transported passengers
 - 3. Roads were often bad and sometimes impossible in bad weather
 - 4. Invention of steam engine in early 19th century revolutionized transportation
 - a. Led to rail transportation
 - b. Brought more settlers to the West
 - c. Opened trade between East and West
- III. Modern U. S. Transportation
 - A. Invention of Internal Combustion Engine led to first automobile in 20th century
 - B. High speed travel by automobile led to more improved roads and highways
 - C. Growing U. S. cities depended upon rail and highway transportation for necessities
 - D. Streets and highways had to be paved and widened to accommodate growing number of vehicles
 - E. Federal, state, and local agencies developed to plan, build, maintain, and regulate transportation.
 - F. Development of automobile assembly line provided basis for U. S. domination of world economy

TEACHER ACTIVITIES

1. Provide student with learning module.
2. Discuss unit and performance objectives.
3. Discuss content and information:
 - Ask student to explain the importance of each of the following and the effects that each had on transportation:
 - a. Domestication of animals
 - b. Invention of wheel
 - c. Invention of the steam engine
 - d. Invention of the internal combustion engine
 - Have students discuss how life might be today without these developments.
 - Show T. M.'s of early forms of land transportation.
4. Arrange a field trip to a museum where the history of transportation has been incorporated.
5. Discuss importance and significance of assembly lines and how they led to world economic domination by the U. S.
6. Discuss activity with students.
7. Supply students with magazines and periodicals and ask them to bring others from home.
8. Have students complete Activity Sheet.
9. Give test and evaluate results.

STUDENT ACTIVITIES

1. Read objectives.
2. Study information sheets.
3. Participate in class discussion.
4. Complete Activity Sheet.
5. Take test.

REFERENCES/RESOURCES

I. References:

1. Hornung, Clarence P., Wheels Across America, A. S. Barnes & Co., New York, 1959.

II. Resources:

1. Information sheets
2. Transparency masters
3. Local museums
4. Periodicals

I. Early Man

A. Nomadic Tribes

- Moved from place to place to find food supplies
- Walked along animal trails

B. Civilized Man

- Settled in small communities
- Domesticated animals for use in farming and transportation (c.6000 B. C.)
- Invention of the wheel was the first step toward modern transportation (c.2700 B. C.)
- Built carts and primitive sleds pulled by man and domesticated animals
- As travel between settlement increased the trails became primitive roads
- New settlements were built where two roads intersected
- As transportation increased the need for newer and better roads became necessary
- Trade routes between settlements were established

II. U. S. Land Transportation

A. Colonial Transportation

- Early roads linked communities and cities
- Travel was on horseback and stage coach
- Explorers moving west used Indian paths and animal trails

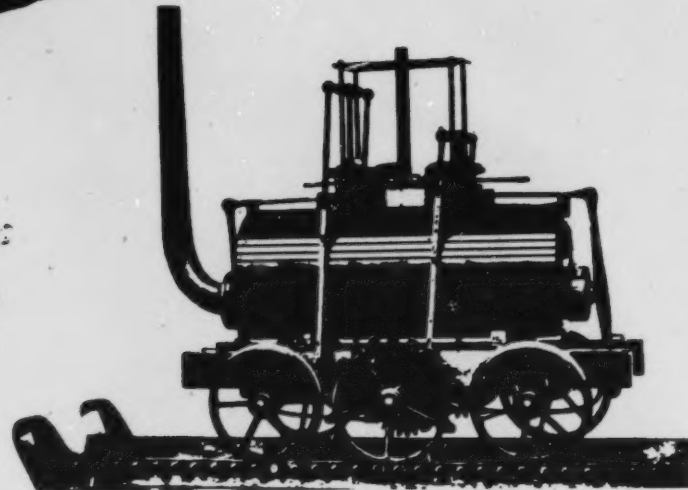
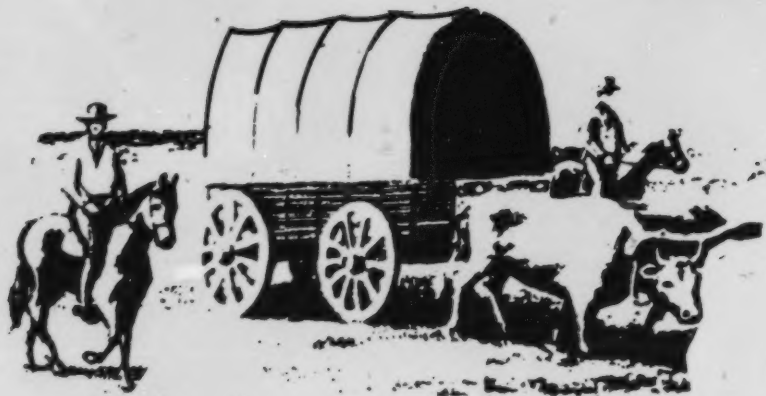
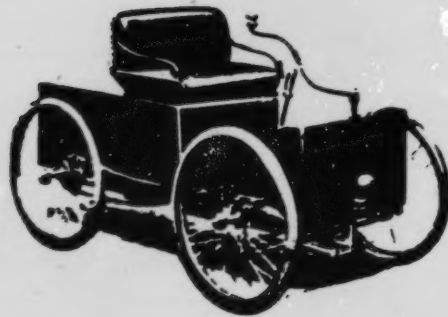
B. Settling the West

- Settlers in horse-drawn covered wagons began moving west
- Stagecoaches transported passengers to settled areas
- Roads were often bad and sometimes impossible in bad weather
- Invention of steam engine in early 19th century revolutionized transportation
 - a. Led to rail transportation
 - b. Brought more settlers to the West
 - c. Opened trade between East and West

III. Modern U. S. Transportation

- A. Invention of Internal Combustion engine led to invention of 1st automobile in the 20th century
- B. High speed travel by automobile led to more improved roads and highways
- C. Growing U. S. cities depended upon rail and highway transportation for necessities
- D. Streets and highways had to be paved and widened to accommodate growing number of vehicles
- E. Federal, state and local agencies were developed to plan, build, maintain and regulate transportation
- F. Development of automobile assembly line provided basis for U. S. domination of world economy

EARLY VEHICLES



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Student Activity #1

GENERAL DIRECTIONS: During this activity you are to construct a notebook on land transportation. Your notebook should be an inexpensive looseleaf type notebook. Use your imagination to title and illustrate the front cover. Then follow the instructions below to construct your notebook.

1. From the magazines and periodicals that you have brought from home and from the ones your instructor provides, find pictures representing at least ten forms of early transportation (stagecoaches, wagons, etc.)
2. Cut the pictures from the magazine and paste each picture on a sheet of notebook paper. Use only one picture per sheet of paper.
3. After each picture explain the form of transportation in the picture. If the picture covers the entire sheet, use another sheet for this information.
4. Explain the form of transportation that would be used today to replace the one in the picture. EXAMPLE: A stagecoach might be replaced today by a bus.
5. Find pictures of the modern forms of transportation that would be used in the same way as the early forms of transportation and include these in your notebook.

SUGGESTED TEST

Match the definition with the terms.

- _____ 1. Walking was their main form of transportation
- _____ 2. First source of power for early transportation
- _____ 3. First step toward modern transportation
- _____ 4. A horse-drawn vehicle used to transport passengers between cities in early U. S.
- _____ 5. Horse-drawn vehicles used to transport settlers
- _____ 6. Led to rail transportation and very important in the settling of the Western U. S.
- _____ 7. Led to invention of 1st automobile.
- _____ 8. Led to world-wide domination of economy by U. S.

- A. Stagecoach
- B. Assembly Line
- C. Domesticated animals
- D. Steam engine
- E. Nomadic tribes
- F. Covered wagons
- G. Internal Combustion engine
- H. Invention of the wheel

TEST ANSWERS

1. E

2. C

3. H

4. A

5. F

6. D

7. G

8. B

EQUIPMENT/SUPPLIES

I. Supplies:

1. Transparencies
2. Looseleaf notebook
3. Magazines

II. Equipment:

1. Overhead projector
2. Projection screen
3. Pointer

TENNESSEE INDUSTRIAL ARTS CURRICULUM

Instructional Section:

LAND TRANSPORTATION

Title of Unit:

URBAN STREETS AND THOROUGHFARES

DESCRIPTION OF UNIT

This unit contains the basic concepts of the urban transportation system on the streets and thoroughfares.

UNIT OBJECTIVES

After completion of this unit the student will be familiar with the basic concepts of urban transportation on the streets and thoroughfares.

PERFORMANCE OBJECTIVES

The students will demonstrate their knowledge of the basic concepts of urban streets and thoroughfares transporter by:

1. Properly using a city street map to find familiar locations and unfamiliar locations and selectory routes to each;
2. By matching ten (10) urban vehicles with their functions in business and industry;
3. By successfully answering at least 75% of the questions on the test covering this unit.

OUTLINE OF CONTENT

I. Urban Streets Organization

- A. Street - a city roadway, usually paved designed for vehicle traffic
 - 1. Streets designated as "streets" run north and south
 - 2. Streets designated as "avenues" run east and west
 - 3. Boulevards are major city streets
 - 4. Feeder streets are major streets that connect business and industrial areas with residential districts
 - 5. Residential streets are smaller streets designated mainly for residential use
- B. Freeway Systems - divide thoroughfares with completely controlled access, usually found in large cities and provides an uninterrupted flow of traffic. Usually links with Interstate highway system for rapid transit through a city. Also provides rapid transportation from one area of the city to another area of city.
 - 1. Loop - a freeway that circles a city
 - 2. Interchange - a point where two or more freeways intersect
 - 3. Ramps - entrances and exits for freeways

II. Urban Vehicles

A. Automobiles

- 1. Private autos
- 2. Business cars

B. Trucks

- 1. Light trucks (1/2 and 3/4 tons)
- 2. Medium weight trucks (1, 1 1/2 and 2 ton trucks)
- 3. Tractor/trailer (confined to major streets)

C. City buses

III. Traffic Control

TEACHER ACTIVITIES

1. Provide student with module.
2. Discuss objective.
3. Discuss content information.
4. Using transparency, show how city streets are organized:
 - explain system of streets and avenues;
 - explain street numbering system;
 - have students discuss why street organization is important to urban transportation.
5. Name several types of urban occupations and have the students discuss how transportation is important to each.
6. Have the student complete Activity #1. Check to see that each has a map. Have students name the places where they found maps available.
7. Have students complete map activities 2, 3 and 4.
8. Have students discuss map activities and show the different routes they selected.
9. Arrange to have a policeman speak to the class on traffic safety and traffic laws.
10. Assist the class in setting up the bicycle obstacle courses for activities #5 and #7. Pylons for this activity may be borrowed from your community's Street Department or from the Highway Department.
11. Give test and evaluate results.

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STUDENT ACTIVITIES

1. Read objectives
2. Study information sheets
3. Participate in class discussions
4. Complete activity sheets
5. Take test

REFERENCES/RESOURCES

I. References:

1. Tennessee Drivers Manual, Tennessee Department of Transportation.

II. Resources:

1. Information sheets
2. Transparency masters
3. City street map
4. Assignment sheets
5. Guest speaker from the Police Department

Terms and Definitions

A. Types of Streets

Street - a city roadway usually paved designed for vehicle traffic
 Thoroughfare - a major city street that serves as routes through the city. They usually link with numbered highways.

Boulevard - a major city street

Feeder Street - a major city street, usually four (4) lanes or more, that connect businesses, industrial and residential areas. These are also known as "major arteries."

Residential Streets - streets designed mainly for residential use.

Freeways - divided thoroughfares. Usually found in large cities, with completely controlled access, cities that provide an uninterrupted link with Interstate highway systems for rapid transit through the city. Provides rapid transportation from one area of the city to another

Loop - a freeway that circles a city

Interchange - a point where two or more freeways intersect

Ramps - entrances and exits from freeways

B. Types of City Vehicles

Automobiles

- private automobile - used for individual and family transportation
- business cars - owned by businesses and used for business reasons. Example: police car, taxi cab, etc.

Trucks

- Pick-up trucks (1/2 ton - 3/4 tons). - used for transportation of light freight and people. Usually rated for 1/2 or 3/4 ton load
- Panel trucks and vans - small enclosed truck used for transporting medium load weights. Example: moving vans, furniture and appliance trucks, etc.
- Tractor/trailer trucks - usually restricted to major streets and thoroughfares and used to transport large tonnage of freight to industries and large businesses
- Specialty trucks - maintenance trucks, wreckers, fire trucks, etc.
- City bus - used to carry passengers to various points within the city

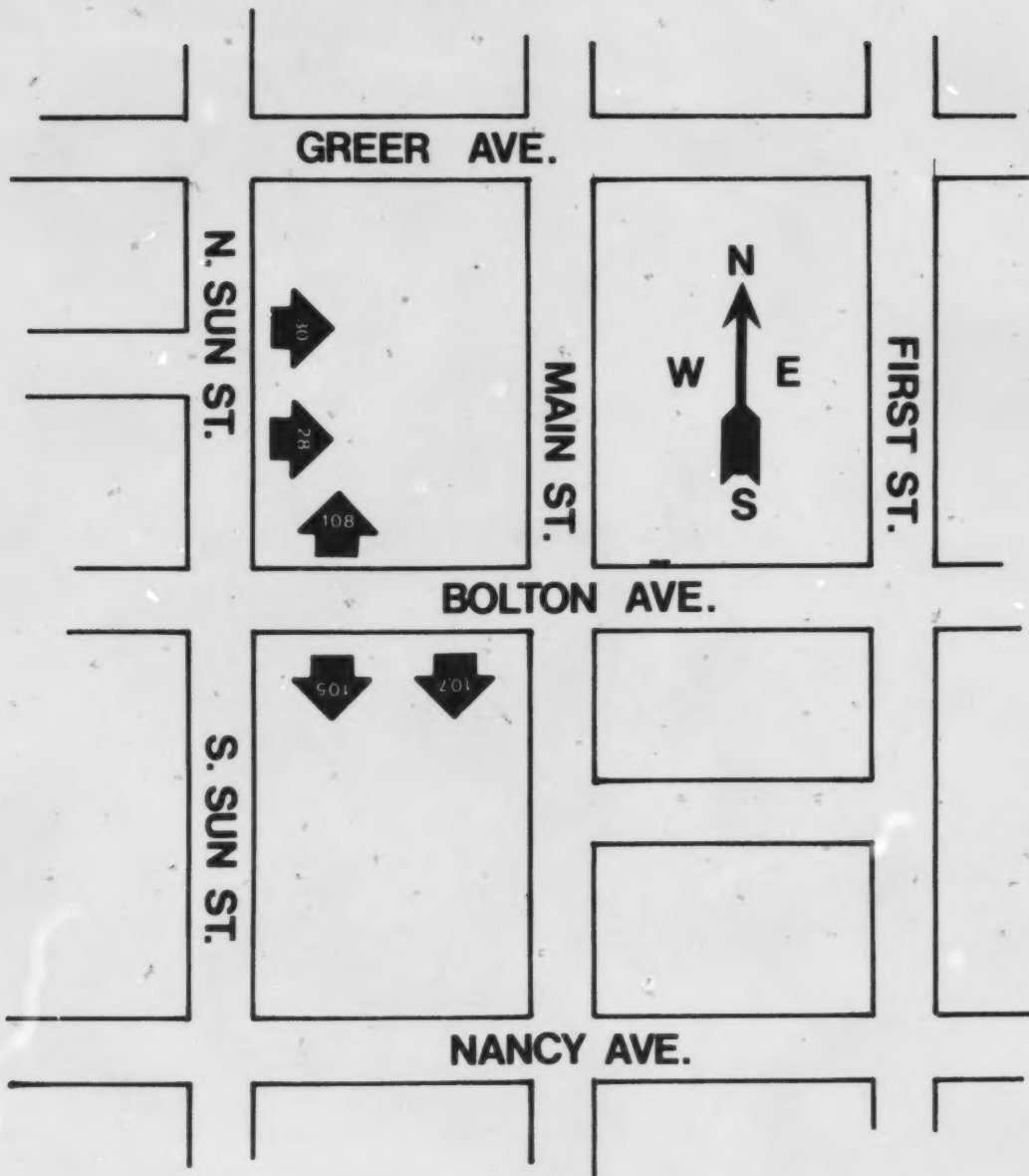
Other vehicles using city streets

- motorcycles, bicycles, etc.

C. Traffic Control

- Vehicles must drive on the right hand side of the street
- Speed limits are posted on city streets and enforced by Police Department
- Traffic at intersections is controlled by:
 1. Traffic lights
 - traffic coming to a green light may proceed through the intersection
 - traffic coming to a red light must stop
 - traffic approaching a yellow light must stop if possible; if there is not time to stop caution should be used
 2. Stop signs
 - traffic coming to an intersection with a stop sign must come to a complete stop before proceeding through the intersection
 3. Yield signs
 - traffic coming to an intersection with a "yield" sign must yield the right of way to other traffic
 4. Traffic police
 - traffic coming to an intersection controlled by a traffic officer must follow his direction regardless of any other signs or lights
 5. Other special signs
 - traffic approaching an intersection should watch for any special instruction signs such as "turn lanes," "no turns," "detours," etc.
- A more complete study of traffic laws will be presented in the following unit on Highway Transportation.

STREET SYSTEM



Student Activity #1

Find where in your community people can go to get a map of the community. (The Chamber of Commerce, some service stations and the American Automobile Association are three that usually have them available.) Go to one of these places and get a street map of your community and bring your map to class. Where did you get your street map? _____

List other places that you found where street maps are available.

Use your map for activities 2, 3 and 4.

- A. Using a marking pen place a small "x" on you map where your home is located.
- B. Place an "x" where your school is located.
- C. With your pen, trace over the route that you normally take to school.
- D. If you did not have a map, write how you would explain to someone how to get from your house to your school.

Student Activity #3

- A. On your map find the location of a business or factory. Mark the location with an "x".
- B. Find a major highway coming into your city. What is the name of the street or the highway number? _____
- C. If you were a truck driver making a delivery to the business or factory that you located, what route would you take if you came into the city on the highway that you located? Trace the route from the city limits to the business or factory.

Student Activity #4

- A. On your map, locate the downtown shopping district of your city. Using a pencil, circle this area.
- B. Plan the shortest route from your home to the downtown shopping area and trace the route with your pencil.
- C. Plan an alternate route from your home to the downtown shopping area that will take you by the business or factory that you located in Activity #3. Trace the alternate route with your pen.

Student Activity #5

In this activity, your class is to construct a bicycle safety course on the campus of your school.

1. With the help of your instructor, plan the route that the course is to follow.
2. Within the course plan at least
 - 3 "stop" signs
 - 2 right angle right turns
 - 2 right angle left turns
 - 1 "S" curve
 - 2 "yield" signs
3. Using poster board, crayons, and marking pens, construct the necessary safety signs, a "Start" sign, and a "Finish Line" sign.
4. Attach the signs to five foot wooden stakes.
5. Using traffic pylons supplied by your instructor, mark the lanes of the bicycle course on the campus or playground area of your school.
6. Place the safety signs in their proper place along the route.
7. Walk along the course that has been laid out and look for hazards such as large rocks, holes, etc.

Student Activity #6

In this activity, you will compete with other students in your class on the bicycle safety course that was constructed in Activity #5.

1. On the day of the activity bring your bicycle to school.
2. A bicycle safety inspection must be made on all bicycles before entering the competition.
3. With your instructor and a safety officer as judges, each student will take turns riding the course. Each student must observe all safety rules and signs.
4. A score of ten points will be given for a perfect ride. Points will be deducted for each safety violation.
5. Scores for the safety course will be recorded for each student and will be used to get a final score after riding the speed course in Activity #8.

Student Activity #7

In this activity your class will design and build a bicylce speed course.

1. With the help of your instructor, plan the route that the course is to take. Plan at least
 - 1 "S" curve
 - 1 sharp left turn
 - 1 sharp right turn
 - A long straightaway to the finish line
2. Using the traffic pylons, lay out the course that you have planned.
3. Clearly mark the start and finish lines.

In this activity each student will compete on the bicycle speed course.

1. On the day of the activity, bring your bicycle to school.
2. Each bicycle must be inspected before riding the course.
3. Each student must have any safety equipment required by the safety officer.
4. Before beginning the competition, each student must ride the course slowly to become familiar with it.
5. Students will then take turns riding the course for competition.
 - Students will sit on their bicycles at the "Starting" line
 - The instructor will give the signal to go
 - Students will ride the course as fast as possible staying within the route. Missing a pylon or going outside the course will eliminate a rider
 - The instructor will keep the time of all riders using a stop watch.
6. The time of the speed course will be recorded.
7. For each point that the rider received on the safety course, one second will be deducted from his time.
8. The rider with the lowest score will win the competition.

Assignment Sheet #1

Directions: Match the following list of occupations in the city with the vehicles that each might use. (In some cases there may be more than one answer.)

- _____ A. Policeman
- _____ B. Person who delivers food from warehouse to supermarket
- _____ C. Member of an emergency medical team
- _____ D. Door-to-door salesman
- _____ E. Telephone repairman
- _____ F. Newspaper carrier
- _____ G. Person who delivers milk from dairy processor to supermarket
- _____ H. Office worker going to work
- _____ I. Doctor going to his office
- _____ J. Television repairman making service calls

- 1. automobile
- 2. motorcycle
- 3. delivery truck
- 4. ambulance
- 5. automobile
- 6. panel truck
- 7. bicycle
- 8. refrigerated truck
- 9. bus
- 10. pick-up truck

SUGGESTED TEST

Directions: Match the terms below with the definitions.

- | | |
|--------------------|-----------------------|
| A. private | G. interchange |
| B. bus | H. avenue |
| C. business car | I. loop |
| D. ramp | J. feeder street |
| E. tractor/trailer | K. freeway |
| F. street | L. residential street |

1. _____ runs north and south
2. _____ small city streets designed for residential use
3. _____ runs east and west
4. _____ a divided thoroughfare with completely controlled access that provides uninterrupted flow of traffic through a city
5. _____ a point where two or more freeways intersect
6. _____ a freeway that circles a city
7. _____ entrances and exits from a freeway
8. _____ a major street that connects business and industrial areas with residential districts
9. _____ used to convey several passengers on city streets to various stopping points in the city
10. _____ usually restricted to major streets and thoroughfares
11. _____ used for individual and family transportation
12. _____ owned by business and used for business reasons

TEST ANSWERS

1. F
2. L
3. H
4. K
5. G
6. I
7. D
8. J
9. B
10. E
11. A
12. C

EQUIPMENT/SUPPLIES

I. Supplies:

1. Transparency
2. Poster boards
3. Crayons and marking pens
4. Five foot wooden stakes
5. Safety pylons
6. City maps

II. Equipment:

1. Overhead projector
2. Projection screen
3. Pointer
4. Stop watch

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

LAND TRANSPORTATION

Title of Unit

RURAL ROADS AND HIGHWAYS

DESCRIPTION OF UNIT

This unit contains the basic concepts of highway transportation in the United States and shows the importance of highway transportation to the economy.

UNIT OBJECTIVE

After completion of this unit the student will be familiar with the concept of highway transportation and will know the general importance of highway transportation to the U. S. economy.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Use a road map to locate highway symbols on a map.
2. Select a primary route and an alternate route to two major cities over Interstate highways and primary highways.
3. Given a list of communities in the state will be able to plan an itinerary to each community and return to his point of departure.
4. Find highway mileage from a road map.
5. Correctly answer at least 75% of the test questions over this material.

OUTLINE OF CONTENT

I. Types of Highways

- A. Local Roads (country roads)
 - 1. carry traffic within a local area
 - 2. sometimes called "farm-to-market" roads
- B. Secondary roads (state highways)
 - 1. link small communities
 - 2. connect local roads to main highways
 - 3. local and secondary roads are built and maintained by local governments such as counties and townships
- C. Primary highways (U. S. Highways)
 - 1. Connect larger communities
 - 2. Built and maintained by state governments with assistance from federal government
- D. Superhighways
 - 1. Turnpikes
 - a. four or more lanes divided by a median strip
 - b. controlled access
 - c. usually connects two metropolitan areas
 - 2. Federal Interstate Highway System
 - a. commonly referred to as Interstate Highways
 - b. connects 90% of the U. S. cities with population of 50,000 or more
 - c. four or more lanes divided by median strip
 - d. completely controlled access
 - e. links communities for uninterrupted flow of traffic
 - 3. Toll highways - usually a turnpike that charges a fee for use of the road

II. Highway Organization and Planning

- A. Local Roads
 - 1. planned and built by local governments
 - 2. some states number the larger local roads
 - 3. some states (including Tennessee) gives them names
- B. Secondary highways
 - 1. planned and built by state government
 - 2. numbering system organized by State Highway Commission
 - a. U. S. highways are marked with black and white shield-shaped "U. S." highway signs
 - b. lowest numbered U. S. highways are in the northern and eastern parts of the country
 - c. odd numbered U. S. highways run north and south
 - d. even numbered U. S. highways run east and west
- C. Interstate Highways
 - 1. planned and built by federal government
 - 2. designed to carry 20% of all vehicle traffic in the U. S.
 - 3. numbering system organized by federal government
 - a. Interstate highways are marked with red, white, and blue, shield-shaped signs

- b. lower numbered Interstate highways are in the South and West
- c. odd numbered Interstate highways run north and south
- d. Even numbered Interstate highways run east and west

III. Highway Transportation Use

- A. For Freight
 - 1. Food to processors and markets
 - 2. Raw material and other necessities and to industries
 - 3. Finished products from industry to consumer
 - 4. necessities (fuel, lumber, etc.) to communities
- B. For people
 - 1. Community to and from work
 - 2. Transportation for rural areas to market
 - 3. Business transportation (sales people, industrial representatives, etc.)
 - 4. Recreation and vacation
 - 5. Evacuation routes in emergencies

IV. Highway Vehicles

- A. For Freight
 - 1. Light trucks (pick-ups, vans, etc.)-transportation of light weight goods
 - 2. Medium trucks (delivery trucks, furniture and appliance trucks, moving vans, etc.) - for transportation of medium weights of freight
 - 3. Tractor/Trailer trucks - diesel powered truck with connecting trailer for transportation of heavy tonnage
 - 4. Refrigerated trucks - any light, medium, or tractor/trailer truck that is refrigerated for the transportation of spoilable goods
 - 5. Bus - has capabilities of transporting small amounts of freight
- B. For people
 - 1. Automobile
 - 2. Light trucks
 - 3. Bus
- C. Specialty vehicles
 - 1. Ambulance
 - 2. Police
 - 3. Maintenance vehicles

TEACHER ACTIVITIES

1. Provide student with learning module.
2. Discuss unit and performance objectives.
3. Have students read information sheets.
4. Secure a copy of the Tennessee Drivers Manual for each student.
5. Have students complete assignment sheet.
6. Arrange to have a guest speaker from a trucking company speak to the class on freight transportation and trucking regulations.
7. Arrange a field trip to trucking company to observe freight handling and moving.
8. Secure a Tennessee state road map for each of your students.
9. Complete demonstrations #1 and 2 for your class.
10. Using T.M.#1, show the three types of highway markers.
11. Using T.M.#2 and #3 explain map legends and their symbols. Have students find various symbols to explain their meanings.
12. Have students complete the activity sheets #1, 2, and 3.
13. Discuss answers to activities.
14. Secure materials and supplies for activity #4.
15. Discuss activity #4 and explain.
16. Have students complete activity #4.
17. Give test and evaluate results.

STUDENT ACTIVITIES

1. Read objectives.
2. Study information sheets.
3. Participate in class discussion.
4. Complete assignment sheet.
5. Complete activity sheets.
6. Take test.

REFERENCES/RESOURCES

I. References:

1. Tennessee Drivers Manual, Tennessee Department of Transportation.
2. Tennessee Road Map, Tennessee Tourist Development, 505 Fesslers Lane, Nashville, TN 37210.

II. Resources:

1. Information sheets.
2. Assignment sheet.
3. Transparency masters.
4. Demonstration.

- I. Types of Highways
 - A. Local (country) Roads
 - carries traffic within a local area
 - B. Secondary Roads
 - also known as state highways
 - link small communities
 - connect local roads to main highways
 - C. Primary highways
 - also known as U. S. Highways
 - connect larger communities
 - D. Turnpikes
 - four or more lanes
 - controlled access
 - usually connect two metropolitan areas
 - E. Federal Interstate Highway System
 - referred to as Interstate Highways
 - connects 90% of U. S. cities with population over 50,000
 - four or more lanes divided by median strip
 - completely controlled access
 - links with freeway system in larger communities for uninterrupted flow of traffic
 - F. Toll Highway
 - usually a turnpike that charges a fee for use of the highway
- II. Highway Organization and Planning
 - A. Local roads
 - financed, planned, and developed by local governments (counties, communities, etc.)
 - in some states these roads are numbered
 - in some states (Tennessee included) these roads are given names
 - B. Secondary Highways
 - financed by state governments with aid from federal government
 - planned and built by State Highway Department
 - numbering system developed by state highway departments
 - C. Primary Highways
 - planned and built by state governments in corporation with the Federal Highway Commission
 - numbering system developed by Federal government
 - marked with black and white, shield-shaped signs
 - lowest numbered U. S. highways are in the Northeast section of the country
 - odd numbered U. S. highways run north and south
 - even numbered U. S. highways run east and west
 - D. Interstate Highways
 - planned and built by federal government
 - maintained by state governments
 - designed to carry 20% of all vehicle traffic in the U. S.

- numbering system developed by Federal Highway Commission
- marked with red, white, and blue shield-shaped signs
- lower numbered Interstate Highways are in the Southwest section of the country
- odd numbered Interstate highways run north and south
- even numbered Interstate Highways run east and west

III. Highway Transportation Use

- A. For freight
 - food and processors and markets
 - raw materials and other necessities to industries
 - finished products from industry to consumers
 - necessities (fuel, lumber, etc.) to communities
- B. For people
 - transportation to and from work
 - transportation from rural areas to markets
 - business transportation (sales people, industrial representatives, etc.)
 - recreation and vacation
 - evacuation routes in emergencies

IV. Highway Vehicles

- A. For freight
 - light trucks (pick-up trucks, vans, etc.) for transportation of light freight
 - medium trucks (delivery trucks, furniture and appliance trucks, moving vans, etc.) - for transportation of medium weights of freight
 - tractor/trailer trucks - diesel powered trucks with connecting trailers for transportation of heavy tonnage freight
 - refrigerated trucks - any size truck that is refrigerated of spoilable goods
 - bus - usually used for transporting people, but is also used to transport small amounts of freight
- B. For people
 - automobiles
 - light trucks
 - bus
 - recreation vehicles
- C. Specialty Vehicles
 - ambulances
 - police cars
 - maintenance vehicles

Interstate marker



**U.S. Highway
marker**



**Tennessee state
route marker**

ROUTE SELECTION

Objective:

To show that routing options are available between most locations.

Materials:

1. One Tennessee road map for teacher.
2. 24 dry mounted road maps, one for each student.

Equipment:

1. Opaque projector.
2. One projection screen.
3. One pointer.

Procedure:

1. Place Tennessee road map under opaque projector so that the area between Nashville and Chattanooga appears on the screen.
2. Direct students to follow along on individual maps.
3. Use pointer to locate Nashville and Chattanooga on screen.
4. Use pointer to trace alternate routes between Nashville and Chattanooga.

Ex. a. I-24

b. U.S. 41

c. U.S. 41 to Monteagle and U.S. 41

Principle:

When alternate routes are available, it is necessary to choose the route best suited to the situation.

DETERMINING MILEAGE

Objective:

To determine mileage between selected locations using mileage indicators given on road map.

Materials:

1. One Tennessee road map for teacher.
2. 24 dry mounted road maps, one for each student.

Equipment:

1. Opaque projector.
2. One projection screen.
3. One pointer.

Procedure:

1. Place Tennessee road map under opaque projector so that the area between Nashville and Chattanooga appears on the screen.
2. Direct students to follow along on individual maps.
3. Point out red and black number found along routes. Black numbers give approximate mileage between cities, junctions, and interchanges. Red numbers give accumulative mileage between red dots. (See map legend.)
4. Locate all red numbers along I-24, between Nashville and Chattanooga. Total these numbers to determine mileage. The numbers are as follows: 33, 15, 14, 16, 6, 6, 17, 27, to total 134.
5. Locate all black numbers along U.S. 70 S. from Murfreesboro to McMinnville. Total these numbers to determine mileage. The numbers are as follows: 14, 5, 8, 4, 7, 2, to total 40.
6. Determine mileage from McMinnville to Crossville as follows: (a) Locate and total all black numbers along U.S. 70 S between McMinnville and Sparta. The numbers are: 2, 3, 9, 2, 4, 6, 1, 1, to total 28. (b) Locate and total all red numbers along U.S. 70, between Sparta and Crossville. The number is 28. Add mileage from McMinnville to Sparta (28) mileage from Sparta to Crossville (28) the total to be (56).

Principle:

Information is available on a road map to determine mileage between locations.

Assignment Sheet #1

- A. Get a copy of the Tennessee Drivers Manual from your instructor.
- B. Read the manual and answer the following questions.
 - 1. What is the maximum legal speed limit on Tennessee highways?
 - 2. What is the stopping distance for a car traveling at 50 mph?
 - 3. If two vehicles came to an intersection with a four-way stop at the same time, which car has the right-of-way?
 - 4. If you are driving a car and come to an intersection with a flashing red light, what should you do?
 - 5. If you are driving a car and come to an intersection with a flashing yellow light, what should you do?
 - 6. What is the maximum safe following distance for cars traveling mph?
 - 7. If there are no sidewalks, pedestrians should walk on which side of the highway?

LT 5.12

ANSWERS TO ASSIGNMENT SHEET #1

1. 55 mph.
2. _____
3. The car on the right.
4. Come to a complete stop.
5. Slow down and use caution going through the intersection.
6. 40 feet.
7. On the left facing traffic.

Student Activity #1

1. Get a Tennessee state road map from your instructor.
2. Find the map's legend and copy each symbol from the legend and explain what each symbol means.
3. Find one of each of the symbols on the map and give its location.

1. Plan a trip from Memphis to Chattanooga over the Interstate Highway System.
2. List the Interstate highway numbers that you would travel on.
3. With a marking pen trace the route that you would take.
4. Select an alternate route from Memphis to Chattanooga over a U. S. highway.
5. Trace the route with your marking pen.

Student Activity #3

Directions: Pretend you work for a parts manufacturing company in Nashville, TN. Your job is to deliver the manufactured parts to a list of communities in the state. Your truck is loaded and ready to go at 8:00 Monday morning. You are to return to Nashville on Thursday night after making all your deliveries. The communities on your delivery route are:

Murfeesboro
McMinneville
Manchester
Shelbyville
Columbia
Laureneburg
Savannah
Bolivar

Memphis
Humboldt
Jackson
Dyersburg
Union City
Paris
Clarksville
Dickson

1. Plan the route that you will take listing the highways that you will take to each destination.
2. List the communities that you will make deliveries to each day so that you can return to Nashville by Thursday night. Place an "x" next to the city where you plan to spend the night on Monday, Tuesday, and Wednesday nights.
3. Your employer will pay you 20¢ per mile for gasoline expenses. Using highway mileage on your map, determine approximately how much your employer will owe you for gasoline.

The AIASA Scramble developed by Dr. Harry T. Smith, Tennessee Tech, and Mr. Donald Sadler, Algood Junior High School.

WHAT IS THE AIASA SCRAMBLE?

The AIASA Scramble is a competitive event in construction and design focusing on the area of transportation. The competitive event is comprised of two parts.

In PART ONE the students construct a four wheel vehicle from the materials, instructions, and the drawings provided in the kit. Tools for the construction of the vehicle will be furnished. When completed, the vehicle will be inspected for both accuracy and quality of construction. After the inspection, the students are then ready for PART TWO.

In PART TWO the students will design and build a passenger compartment within the vehicle capable of insuring maximum passenger safety. This must be done using only the materials provided and without altering the basic vehicle design. The only passenger, in this instance, is a Grade A Large EGG! When the vehicle is finished, it and the passenger will be test crashed into a barrier. The passenger should withstand the force of the collision if the vehicle has been properly designed for maximum passenger safety.

PROCEDURES

1. Enter the work area.
2. Obtain kit from the chairperson.
3. Check the kit for any missing items (refer to the enclosed bill of materials).
4. Obtain your tools from the chairperson (check your tools against the tool list below).
5. Wait for the signal from the chairperson to begin work.

TOOL LIST

- | | |
|----------------------|-----------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill bit | 9. Hand screw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exacto knife |

MATERIALS FOR PART ONE

- (1) 3/4" X 3 1/2" X 8" pine board (chassis)
- (1) 1 1/2" X 1 1/2" X 4" pine block (front panel)
- (1) 1" X 3" X 4" pine block (rear panel)
- (4) #8 X 1 1/2" FH wood screws
- (2) 1/8" X 5" steel rods (Axles)
- (4) small eye screws
- (4) wheels
- (1) 2" X 4" emery cloth

MATERIALS FOR PART TWO

- (1) plastic egg
- (3) large rubber bands
- (1) piece of plastic foam
- (1) piece adhesive backed foam
- glue
- thumbtacks

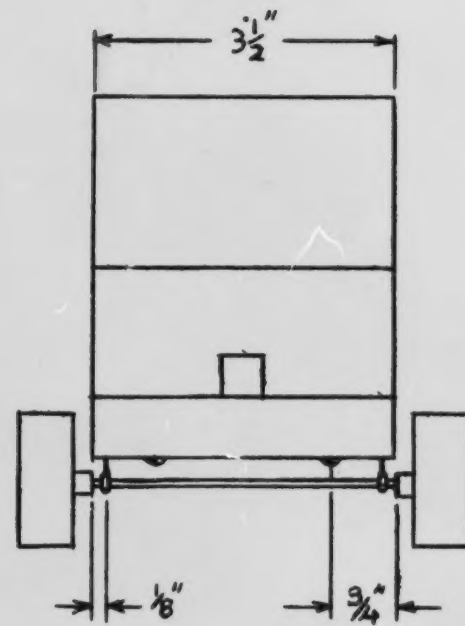
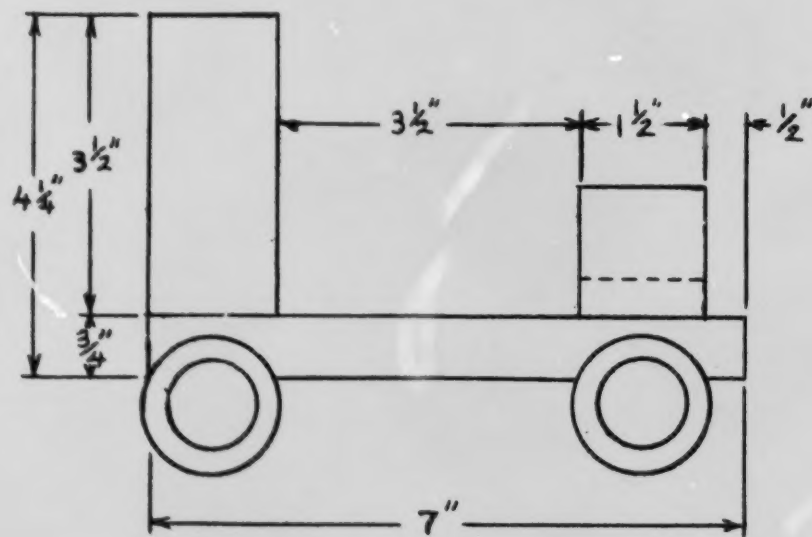
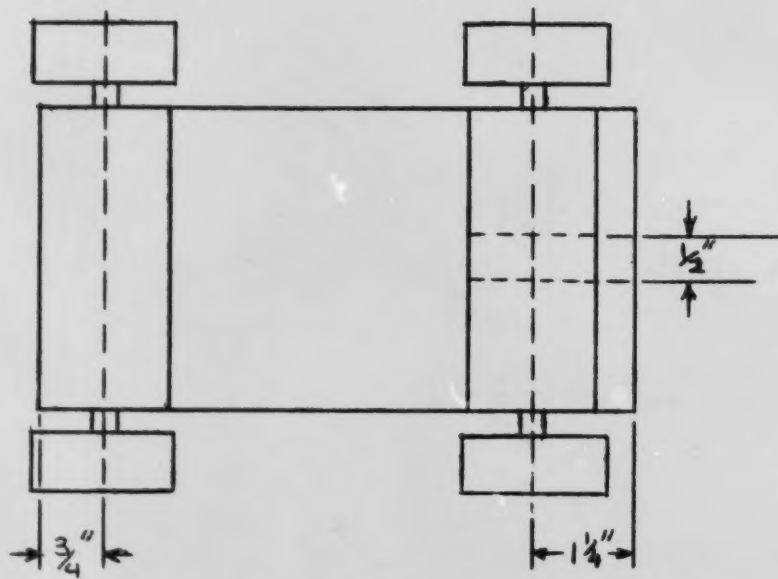
VEHICLE CONSTRUCTION (PART ONE)

1. Cut chassis to 7" in length.
2. Cut front panel to 3 1/2".
3. Cut dado joint (see "A" in exploded view).
4. Cut rear panel to 3 1/2".
5. Lay out lines at 1/2" and 2" from one end of chassis. This is where the front panel is attached.
6. Drill 2 holes in front of chassis for screws to hold front panel.
7. Drill 2 holes in rear of chassis for screws to hold rear panel. Rear panel should be flush with end of chassis. (See "C" in exploded view.)
8. Assemble front and rear panel with wood screws.
9. Screw in eye screws to hold axles.
10. Cut 1/8" steel rods (axles) to 4 3/8" (use emery paper to smooth rough ends.)
11. Assemble axles and wheels.
12. Have vehicle inspected before beginning PART TWO.

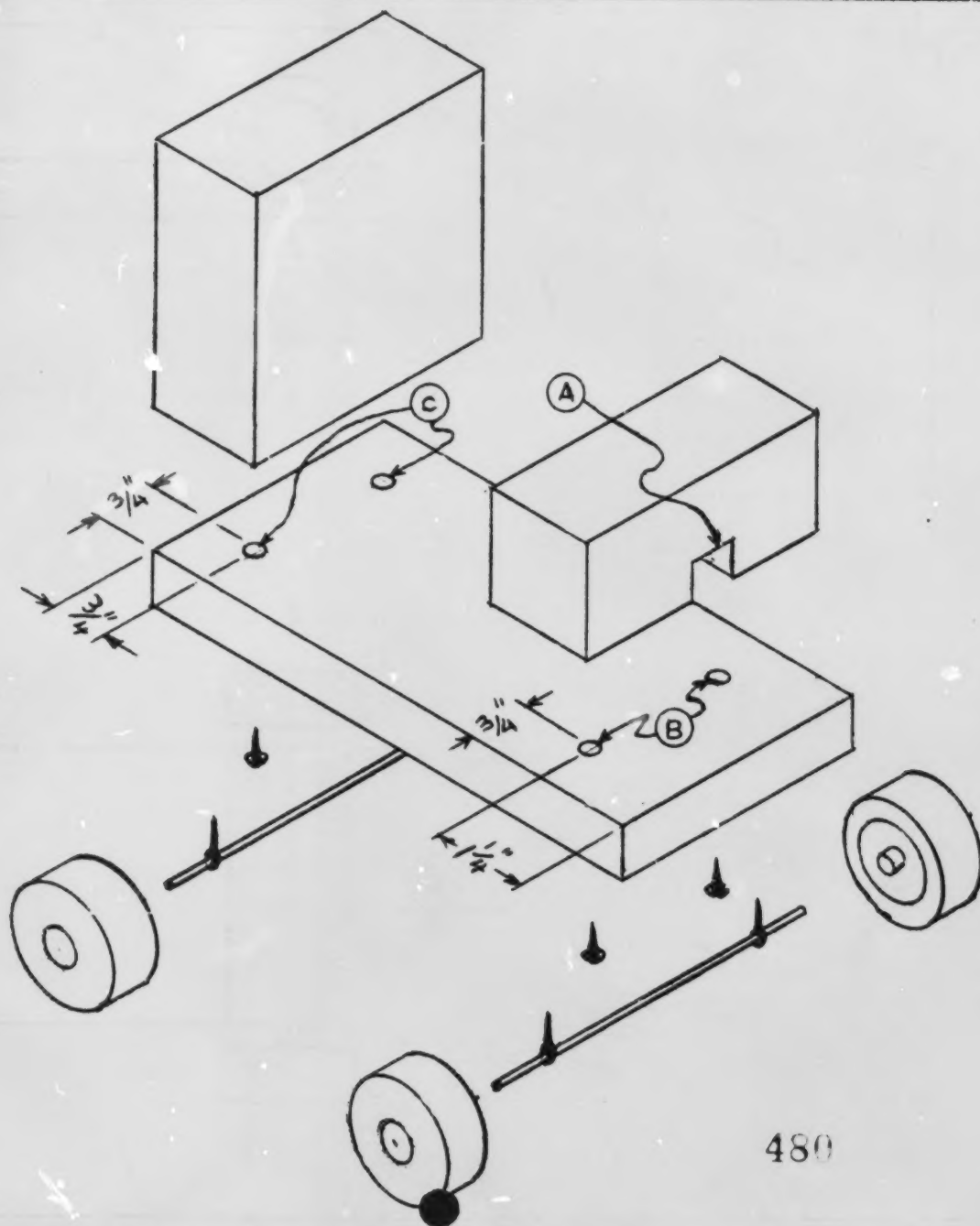
LT 5.18

PART TWO

1. Using the materials provided in your kit, design the passenger compartment of your vehicle for maximum safety.
2. Do not alter the basic design of the vehicle.
3. The following regulations must be followed:
 - a) No more than the dark portion of the bottom of the egg may be sitting in foam.
 - b) No more than THREE lashings (seat belts) of rubber bands may be used.
 - c) When testing, a cracked egg is the same as a scrambled (dead) egg!
4. If in doubt of any of the regulations check with the chairperson.
5. When you have finished return all tools to the chairperson and clean up your work area.
6. Present your vehicle to the chairperson for the barrier testing.



S.A.-4 / LT 5.18-A



SUGGESTED TEST

Directions: Match the terms with their definitions.

- | | |
|-------------------------------|--------------------------|
| A. Interstate Highway | H. East and West |
| B. Primary Highway | I. North and South |
| C. State highway | J. Southwest |
| D. Local road | K. Northeast |
| E. Map legend | L. Bus |
| F. U. S. Highway Marker | M. Pick-up truck |
| G. Interstate Highway Markers | N. Tractor/trailer truck |
| | O. Refrigerated truck |

- _____ 1. Used to transport a large number of passengers over highways and is capable of carrying small amounts of freight.
- _____ 2. Shows symbols and other information about road maps.
- _____ 3. Section of the country where the lower numbered Interstate Highways are located.
- _____ 4. Used to transport "spoilable" freight.
- _____ 5. Built by federal government and designed to connect 90% of the U. S. cities with population over 50,000.
- _____ 6. Direction of travel for odd numbered U. S. and Interstate highways.
- _____ 7. Built by counties and local communities
- _____ 8. Used to carry light freight and small number of passengers
- _____ 9. Section of the country where lower numbered U. S. highways are located
- _____ 10. Built by state government with federal assistance. Also known as U. S. Highways
- _____ 11. Used to transport heavy tonnage of freight
- _____ 12. Direction of travel for even numbered U. S. and Interstate Highways
- _____ 13. Built by state government to connect smaller communities
- _____ 14. Black and white, shield-shaped highway signs
- _____ 15. Red, white, and blue, shield-shaped highway signs

TEST ANSWERS

1. L
2. E
3. J
4. O
5. A
6. I
7. D
8. M
9. K
10. B
11. N
12. H
13. C
14. F
15. G

EQUIPMENT/SUPPLIES

I. Supplies:

1. Transparencies
2. Marking pens
3. Road maps for instructor and students
4. Drivers manuals for instructor and students

II. Equipment:

1. Overhead projector
2. Opaque projector
3. Projection screen
4. Pointer

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Instructional Section:

LAND TRANSPORTATION

Title of Unit:

RAILROADS

DESCRIPTION OF UNIT

This unit contains the basic concept of railroad transportation in the United States and shows the importance of railroad transportation to our economy.

UNIT OBJECTIVE

After completion of this unit the student will be familiar with the basic concepts of railroad transportation in the United States and will know the general importance of railroad transportation to the U. S. economy.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Match 15 different freight cars with their functions;
2. Plan and construct a simulated railroad system in the classroom that will efficiently transport freight from five different industries to three different cities;
3. List 2 advantages and 2 disadvantages of railroad transportation to highway transportation;
4. Correctly answer 75% of the questions on a test over the material.

OUTLINE OF CONTENT

I. Freight Service

A. Advantages to highway freight transportation

1. capable of transporting heavier amounts of freight
2. capable of carrying a wider variety of types of freight (bulk, gases, and finished products)
3. less expensive and conserves more fuel

B. Disadvantages to highway freight transportation

1. most shipments cannot be made direct to their destination but must be transferred to truck transportation for final delivery
2. slower than highway transportation

C. Freight Cars and Their Uses

1. Box Car--enclosed freight car with wide door for handling boxed and packaged bulk freight
2. Gondola--open top or covered car used to haul heavy bulky freight such as metal products
3. Open Hopper--open top car used to haul bulk metal ores, coal, etc.
4. Covered Hopper--a closed, top hopper used to haul bulk goods that requires protection from the weather such as wheat corn, and other grains.
5. Tank Car--cylinder shaped car used for hauling oil and other liquids
6. Flat car--used to carry complete loads - may be modified to carry logs
7. Piggy-back flatcar--a common flatcar used to haul truck trailers that are loaded with freight
8. Two-level rack car--used to transport automobiles and pick-up trucks
9. Refrigerated car--an enclosed, insulated box car that is refrigerated for hauling perishable freight
10. Stock car - a box car with slatted sides used for hauling livestock
11. Caboose--the last car on a train; used as living quarters for the train crew

D. Freight Train Organization

1. Train yard--large switching area containing moving parallel tracks used to organize trains as to type freight and destination
2. Identification label--a color coded label on each freight car that gives necessary information about the car - car's owner, kind of car, destination, etc.

II. Urban Passenger Service

- A. Computer trains--provides rapid transportation from suburban to urban areas.
- B. Subways--underground rail transportation that provides rapid transportation within a large metropolitan area.
- C. Monorails--passenger train using one rail - usually elevated for rapid transportation within a city.
- D. Elevated railroad--a commuter railroad that is elevated above the streets in a city.

III. Long Distance Passenger Service

- A. Amtrack--government sponsored passenger railroad
- B. Special excursion--chartered and special run passenger railroads.

TEACHER ACTIVITIES

1. Provide student with learning module.
2. Discuss unit and performance objectives.
3. Discuss content and information:
 - show T. M. #1 and discuss each freight car; ask students to name various freight that might be transported in each;
 - show T. M. #2 and explain how the color coded Identification label helps identify each car - tell students to look for these labels the next time they see a train (each freight car will have one).
4. Have students complete assignment sheet.
5. Discuss activity assignment with the students.
6. Show T. M. #3 and explain the railroad system as shown - make suggestions and answer questions.
7. Secure the results and materials for use in activity.
8. Have students complete the activity.
9. Discuss the results of the activity.
10. Make recommendations on how they might improve their railroad.
11. Compare the class activity railroad to a real railroad system. (Leave class railroad in place to be used in next unit.)
12. Give test and evaluate results.

STUDENT ACTIVITIES

1. Read objectives
2. Study information sheets
3. Complete assignment sheets
4. Complete activity sheets
5. Take test

REFERENCES/RESOURCES

References

1. Hornung, Clarence P., Wheels Across America, A.S. Barnes & Co., New York, 1959

Resources

1. Information Sheets
2. Transparency Masters
3. Assignment Sheets

Terms and Definitions

1. Railroad - a line of tracks providing a runway for wheels.
2. Freight Car - a railroad car on a train used for transporting freight.
3. Passenger Car - a railroad car used for transporting passengers.
4. Locomotive - the engine used to pull the train.
5. Monorail - a single rail serving as a track for cars that are balanced upon it or suspended from it.
6. Switch Yard - an area of several parallel tracks used for organizing trains in order of their destination.
7. Switch Engine - a locomotive used in the switch yard to push or pull freight cars onto the switch yard tracks.
8. Side track - a set of tracks parallel to the main track used for pulling trains or freight off the main track.

I. Freight Service

A. Advantages to highway transportation

- carries a wider variety of types of freight
- less expensive
- conserves more fuel

B. Disadvantages

- usually cannot make direct shipments to final destination; freight must be transferred to truck for final delivery
- slower than highway transportation

C. Freight Cars and Their Uses

Box Car - enclosed freight car with side door used for handling general freight, boxed and packaged goods

Gondola - open top or covered car used to haul heavy, bulky freight such as metal products

Open Hooper - open top car used to haul bulk freight such as metal ore, coal, etc.

Covered Hooper - a closed top car used to haul bulk freight that requires protection from the weather such as wheat, corn and other grains

Tank Car - cylinder shaped car used for hauling oil and other liquids

Flat Car - used to carry compact loads such as lumber, heavy equipment, etc.

Piggy-back flat car - a common flat car used to transport truck trailers that are loaded with freight

Two-level rack car - used to transport automobile and light trucks

Refrigerated Car - an enclosed, insulated box car that is refrigerated for hauling perishable freight

Stock Car - a box car with slatted sides used for hauling livestock

Caboose - the last car on a train; used as living quarters for the train crew

D. How Freight Trains are Made Up

- freight cars are pulled into a switch yard and routed to one of several tracks according to destination
- identification labels on each freight car tells switch yard operator information about the car and its contents for correct routing
- when all the cars on the train are connected on a track, the caboose is connected
- a locomotive pulls the train from the switch yard onto a main track and is headed for its final destination

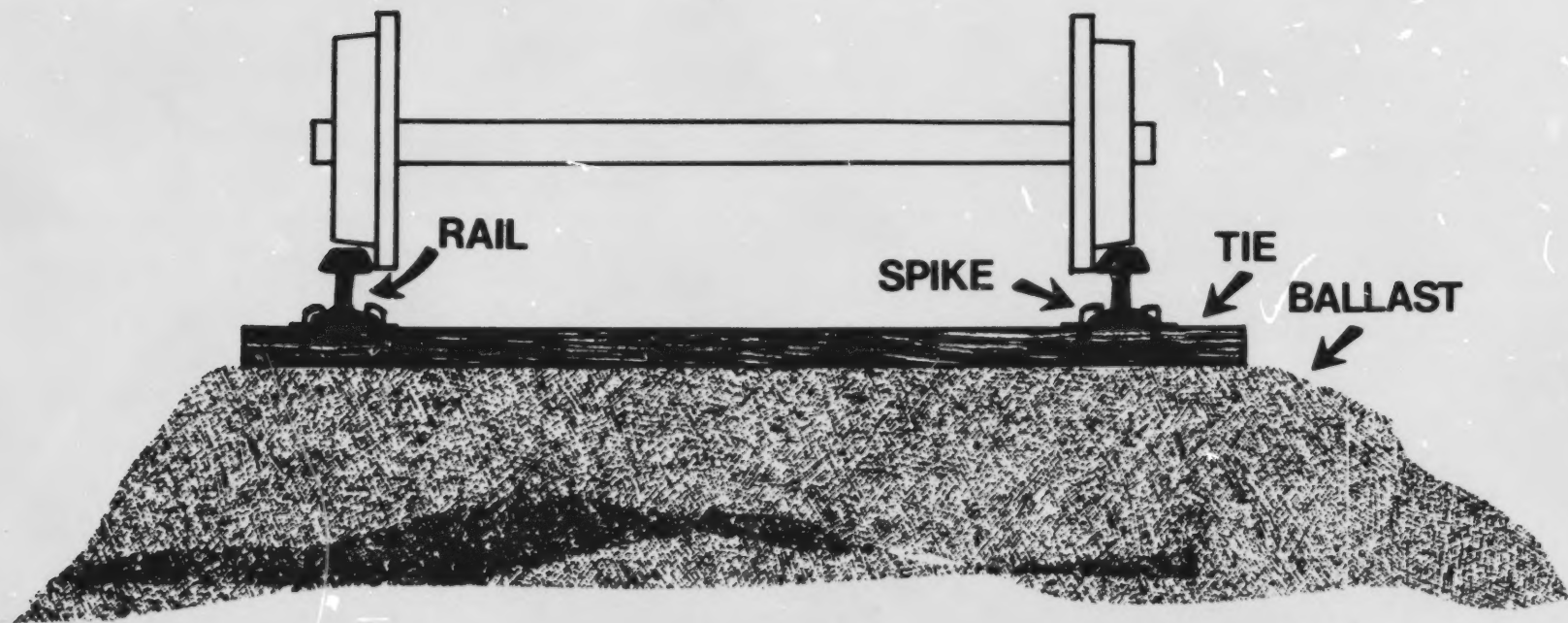
II. Urban Passenger Service

- A. Commuter trains - provides rapid transportation round trip from suburban to urban areas
- B. Subways - underground rail transportation that provides rapid transportation with a large metropolitan area
- C. Monorail - passenger trains using one rail
- D. Elevated railroad - a commuter railroad that is elevated above city streets - often referred to as "els"

III. Long Distance Passenger Service

- A. Amtrack - government sponsored passenger railroad
- B. Special excursion - privately owned charter and special run passenger trains

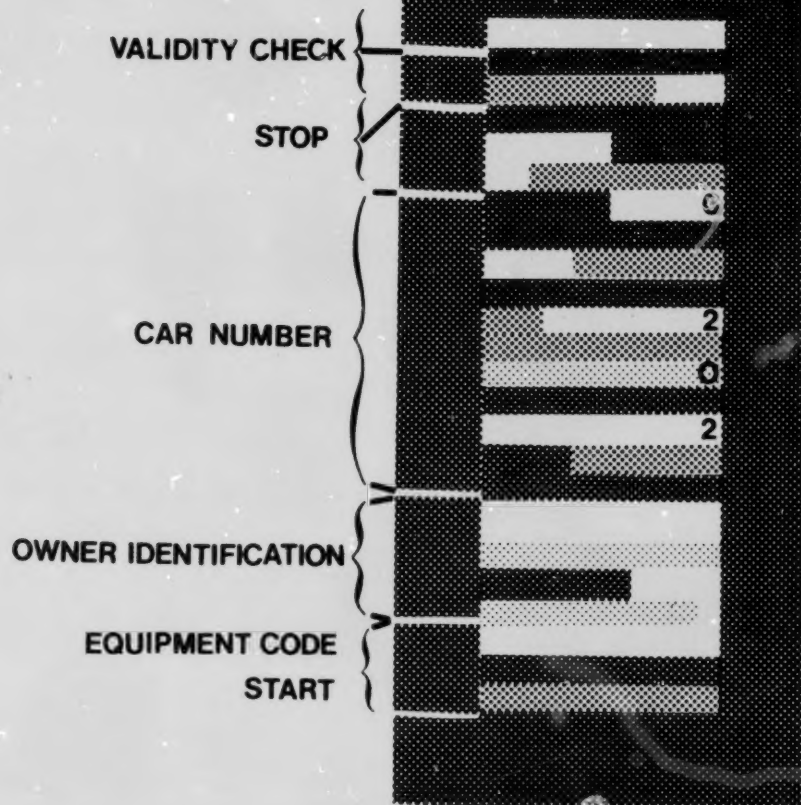
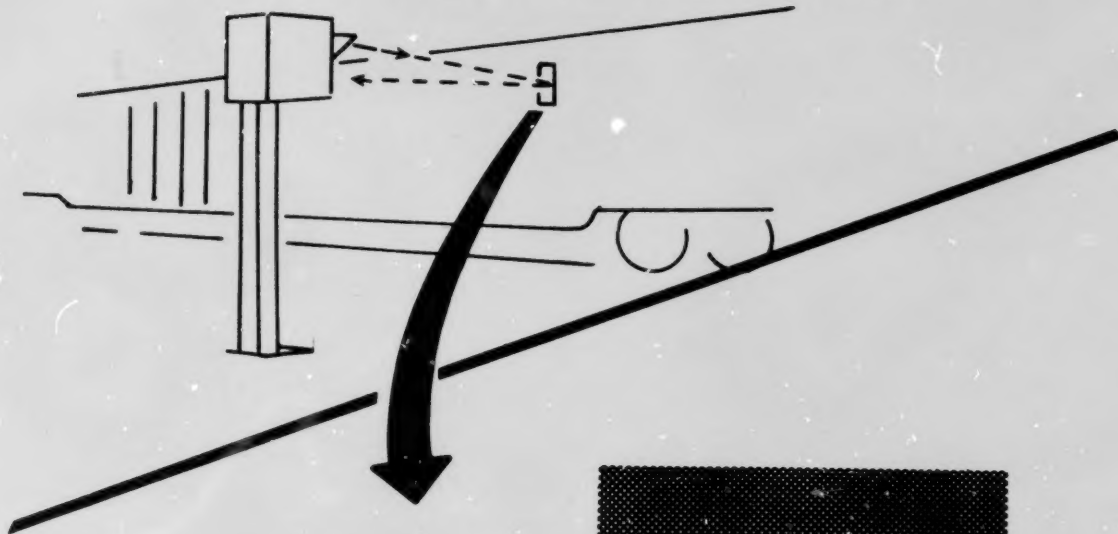
TRAIN WHEELS and TRACKS



493

494

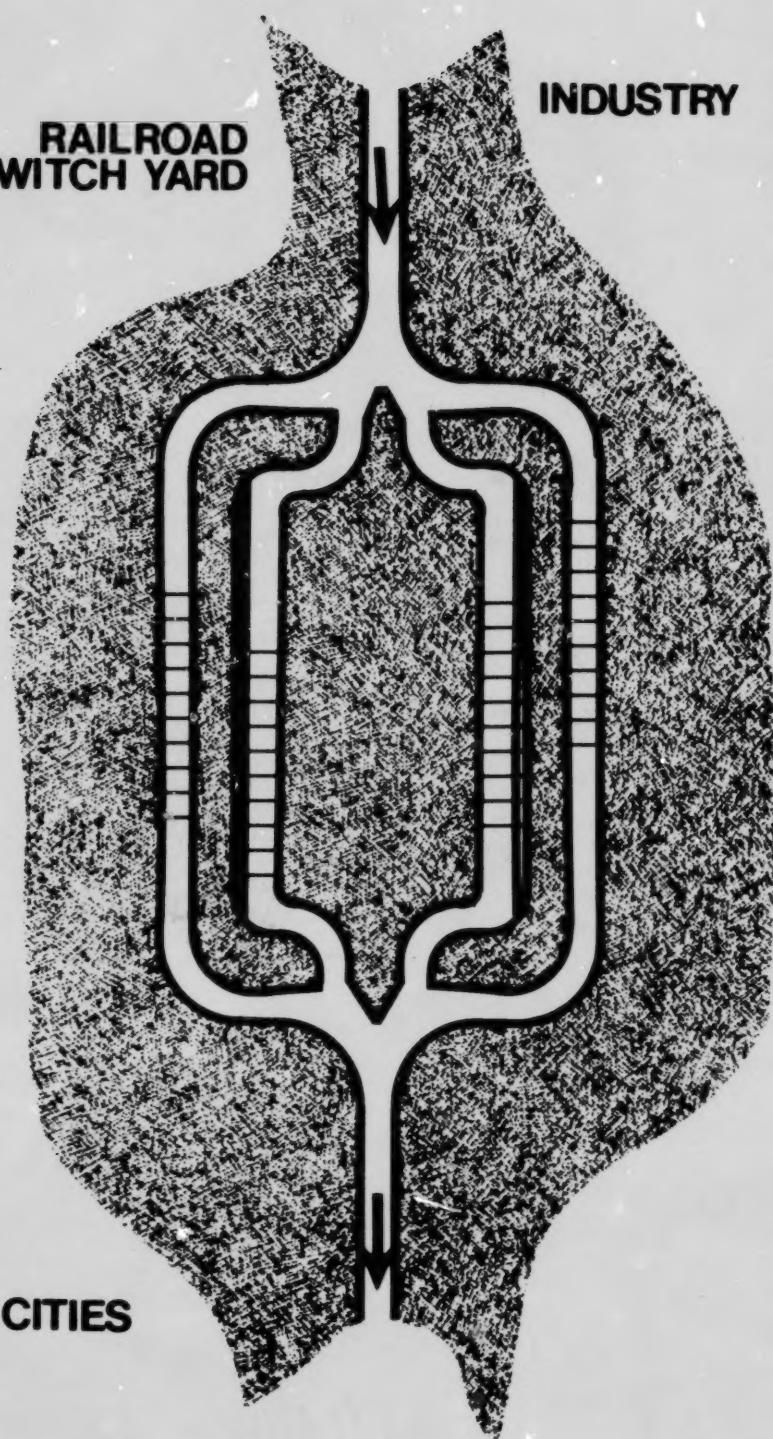
AUTOMATIC CAR IDENTIFICATION



**RAILROAD
SWITCH YARD**

INDUSTRY

CITIES



Assignment Sheet #1

Using the information sheets, match the rail cars to their functions

- | | |
|-------------------------|-----------------------------|
| _____ A. Box Car | _____ F. Caboose |
| _____ B. Gandola | _____ G. Stock car |
| _____ C. Open hopper | _____ H. Tank car |
| _____ D. Covered hopper | _____ I. Refrigerator car |
| _____ E. Flat car | _____ J. Two-level rack car |
| | _____ K. Piggy-back Flatcar |

1. Hauling liquids
2. Hauling livestock
3. Hauling heavy compact loads
4. Hauling packaged, boxes, and general freight
5. Hauling heavy, bulky freight such as metal products
6. Hauling grains
7. Provides living quarters for train crew
8. Hauling automobiles and pick-up trucks
9. Hauling metal ore, coal, etc.
10. Hauling loaded truck trailers
11. Hauling perishable freight

LT 6.11

SUGGESTED ANSWERS to ASSIGNMENT SHEET #1

A. 4

B. 5

C. 9

D. 6

E. 3

F. 7

G. 2

H. 1

I. 11

J. 8

K. 10

Student Activity #1

Building a Railroad Transportation System in the Classroom

1. Divide your class into six groups. Each group will have one of the following industries with freight to be shipped by rail
 - Group #1 - Grain Company shipping wheat
 - Group #2 - Coal Mining Company
 - Group #3 - Carpet Manufacturing
 - Group #4 - Produce Company shipping fresh produce
 - Group #5 - Oil Company
 - Group #6 - Railroad Company
2. Each group should move to an assigned area in the classroom. Groups #1 thru #5 are to construct eight freight cars to represent their industries. Directions for constructing the freight cars are as follows:
 - Group #1 - Activity Sheet 1-A
 - Group #2 - Activity Sheet 1-B
 - Group #3 & #4 - Activity Sheet 1-C
 - Group #5 - Activity Sheet 1-D

Directions for constructing the locomotives and cabooses for froup #6 is on Activity Sheet 1-E & 1-F.
3. Each group will construct their required cars. Be sure to paint or label your cars.
4. Each group is to set aside a small area in the classroom that will represent their factory.
5. Group #6 should designate a larger area toward the center of the room for a switch yard.
6. Using 1/2" masking tape to represent rails (you may use chalk instead of masking tape if you have permission to have tracks on the floor) construct a system of railroads to transport the products from the five industries to the three cities. For efficiency of transportation, each industry must first ship their freight to the switch yard. The switch yard, designed by Group #6 will be used to organize three trains to transport the freight to the three cities. Your instructor will show you an example of how one classroom was organized. You might want to re-arrange your classroom using desks, chairs, tables, and other items as natural boundaries.
7. Each industry will request the Railroad Company to send a locomotion to their factory to transport their products to the three cities according to the following list:
 - City A has ordered:
 - 3 car loads of wheat
 - 5 car loads of coal
 - 4 car loads of oil
 - 2 car loads of carpets
 - 2 car loads of produce

City B has ordered:

- 2 car loads of wheat
- 1 car load of coal
- 3 car loads of carpets
- 1 car load of produce

City C has ordered:

- 3 car loads of wheat
- 2 car loads of coal
- 1 car load of oil
- 5 car loads of carpets
- 3 car loads of produce

8. The Railroad Crew will send a locomotive to each factory and transport the cars to the switch yard.
9. At the switch yard they will organize each train according to destination.
10. The railroad system should be constructed with sidetracks at each city. The Railroad Crew will take one train to each city, leave the loaded cars on the sidetrack then return to the switch yard. The railroad system must be constructed so that the locomotives and trains can reach their destinations and return using switches and sidetracks.
11. After the project is completed, each student is to write a short paper describing the problems encountered and telling how the system could be improved.

Student Activity #2

Constructing a covered hopper for group #1

General Directions: Construct eight covered hopper following the instructions below.

Tool List

- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill kit | 9. Hand saw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

Materials

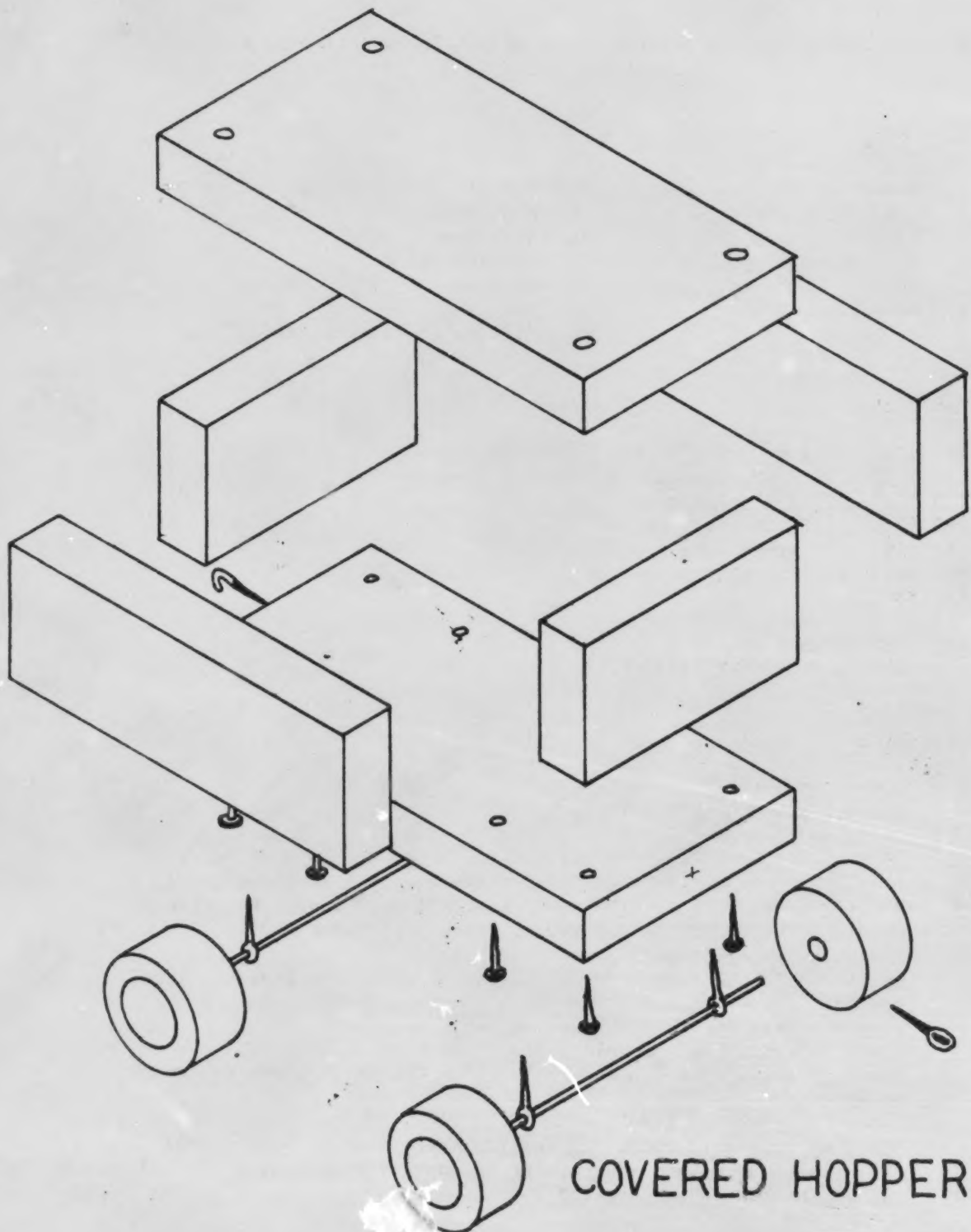
- (1) 3/4" x 3 1/2" x 8" pin board (chassis)
- (2) 3/4" x 2" x 4" pine block (front & rear panels)
- (2) 3/4" x 2" x 6" pine block (side panels)
- (1) 3/4" x 3 1/2" x 8 pine board (top)
- (12) #8 x 1 1/2" FH wood screws
- (2) 1/8" x 5" steel rods (axles)
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) hook latch & eye
- paint & brushes as desired.

Directions for Construction

- 1. Cut chassis to 7" in length.
- 2. Cut front and rear panels to 3 1/2".
- 3. Cut side panels to 5 1/2".
- 4. Drill 2 holes in front of chassis for screws to hold front panel. Front panel should be flush with chassis.
- 5. Drill 2 holes in rear of chassis to hold rear panel. Rear panel should be flush with end of chassis.
- 6. Assemble front and rear panels with wood screws.
- 7. Drill 2 holes in each side of chassis to hold side panels. Side panels should be flush with sides of chassis. (See exploded view).
- 8. Assemble side panels with wood screws.
- 9. Cut top panel to 7" in length.
- 10. Drill 2 holes in the front of the top panel and 2 holes in the rear of the top panel to attach top panel to front and rear panels. (See exploded view).
- 11. Assemble top panel to front and rear panels with wood screws.

LT 6.15

12. Screw in eye screws to hold axles.
13. Cut 1/8" steel rods (axles) to 4 3/8". Use emery paper to smooth rough ends.
14. Assemble axles and wheels.
15. Screw an eye screw into the front center chassis (See exploded view).
16. Screw a hook latch into the rear center chassis. (See exploded view).
17. Paint the finished car as desired.



COVERED HOPPER

Constructing an open hopper for Group #2

General Directions: Construct eight open hoppers following the instructions below.

Tool List

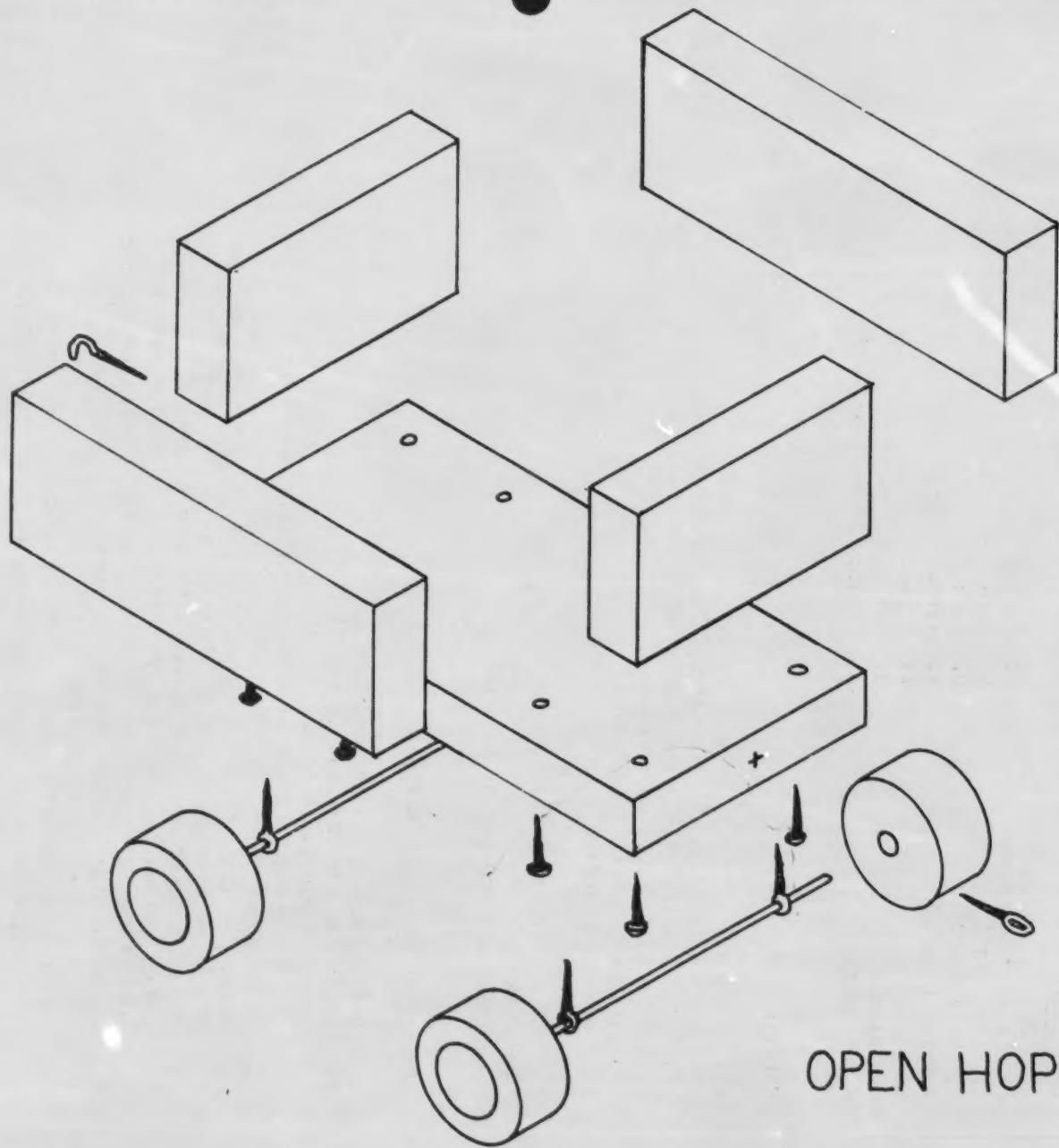
- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill bit | 9. Hand screw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

Materials

- (1) 3/4" x 3 1/2" x 8 pine board (chassis)
- (2) 3/4" x 2" x 4" pine blocks (front & rear panels)
- (2) 3/4" x 2" x 6" pine boards (side panels)
- (8) #8 x 1 1/2" FH wood screws
- (2) 1/8" x 5" steel rods
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) hook latch & eye
- paint and brushes as desired.

Directions for Construction

- 1. Cut chassis to 7" in length.
- 2. Cut front and rear panels to 3 1/2 ".
- 3. Cut side panels to 5 1/2".
- 4. Drill 2 holes in front of chassis for screws to hold front panel. Front panel should be flush with chassis. (See exploded view).
- 5. Drill 2 holes in rear of chassis to hold rear panel. Rear panel should be flush with end chassis. (See exploded view).
- 6. Assemble front and rear panels with wood screws.
- 7. Drill 2 holes on each side of chassis to hold side panels. (See exploded view).
- 8. Assemble side panels with wood screws.
- 9. Screw in eye screws to hold axles.
- 10. Cut 1/8" steel rods (axles) to 4 3/8". Use emery paper to smooth rough ends.
- 11. Assemble axles and wheels.
- 12. Screw eye screw to front center of chassis (See exploded view).
- 13. Screw hook latch into rear center of chassis (See exploded view).
- 14. Paint finished car as desired.



OPEN HOPPER

506

Constructing a box car for group #3 and a refrigerated car for group #4.

Tool list

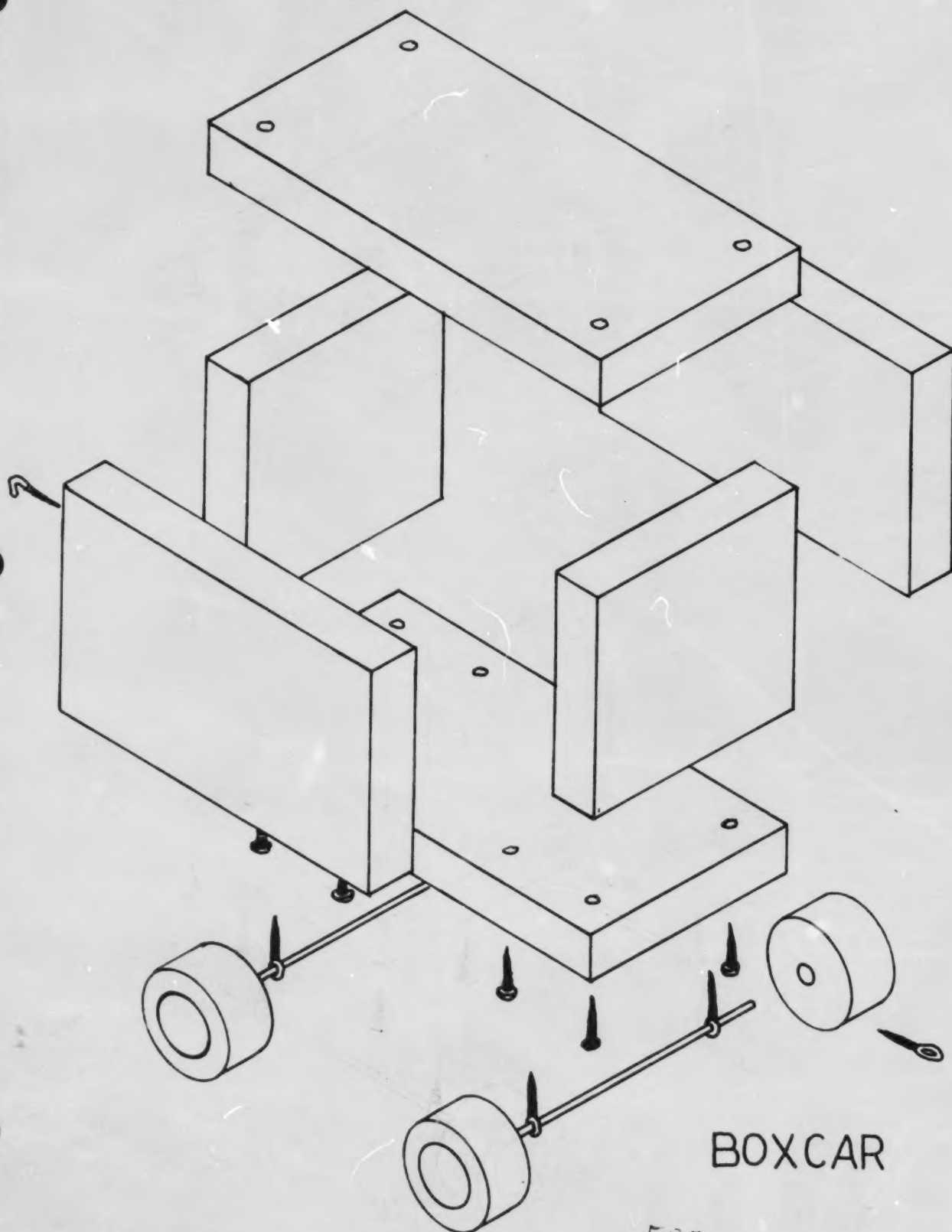
- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill kit | 9. Hand saw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

Materials

- (2) 3/4" x 3 1/2" x 8" pine board (chassis top)
- (2) 3/4" x 3 1/2" x 4" pine block (front and rear panel)
- (2) 3/4" x 3 1/2" x 6" pine boards (side panels)
- (12) #8 x 1 1/2" FH wood screws
- (2) 1/8" x 5" steel rods (axles)
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) hook latch & eye
- paint and brushes as desired

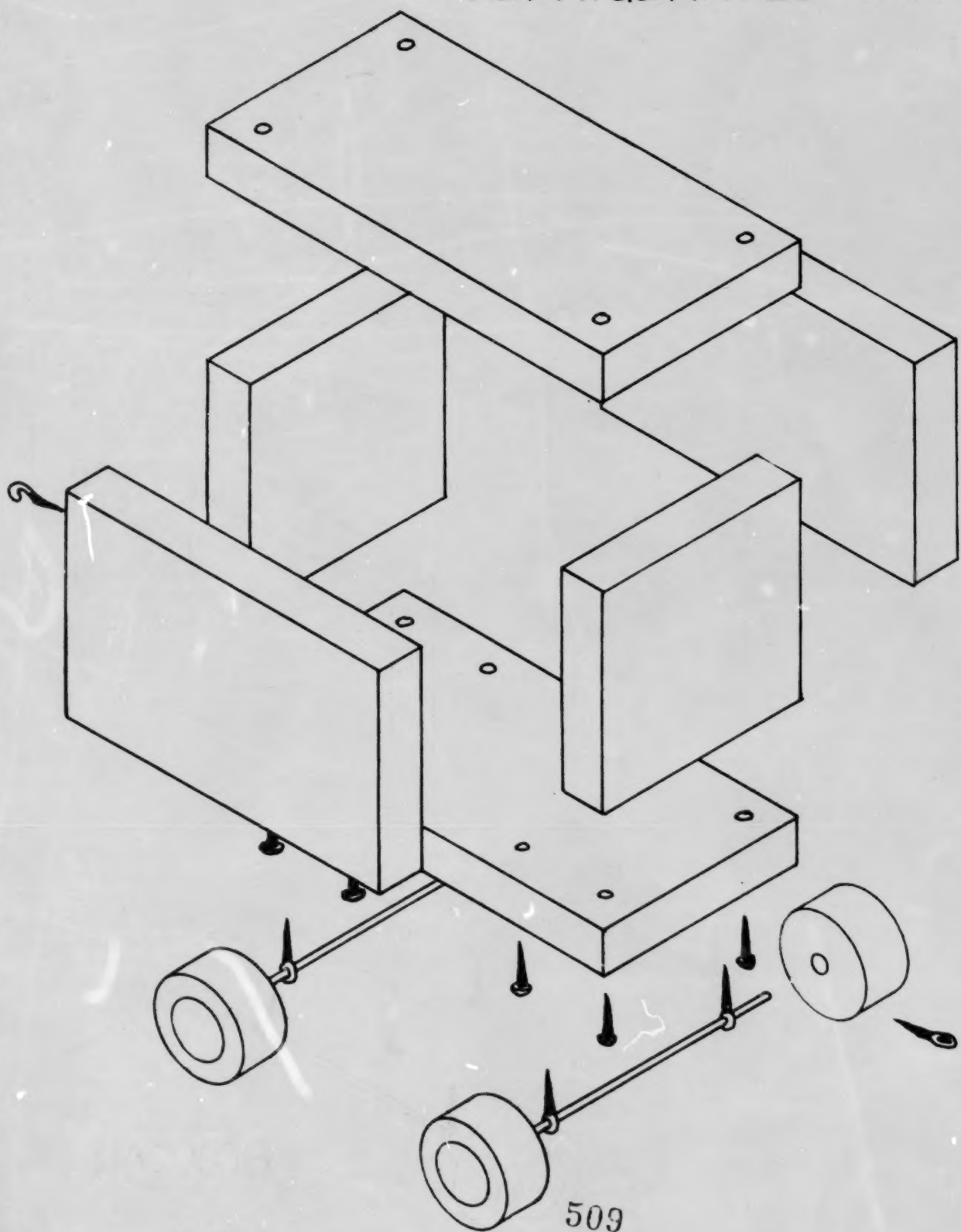
Directions for Construction

- 1. Cut chassis to 7" in length.
- 2. Cut front and rear panels to 3 1/2".
- 3. Cut side panels to 5 1/2".
- 4. Drill 2 holes in front of chassis for screws to hold front panel. Front panel should be flush with end of chassis.
- 5. Drill 2 holes in rear of chassis to hold rear panel. Rear panel should be flush with end of chassis.
- 6. Assemble front and rear panels with wood screws.
- 7. Drill 2 holes in each side of chassis to hold side panels. Side panels should be flush with sides chassis. (See exploded view).
- 8. Assemble side panels with wood screws.
- 9. Cut top panel to 7" in length.
- 10. Drill 2 holes in the front of the top panel and 2 holes in the rear of the top panel to attach top panel to front and rear panels. (See exploded view).
- 11. Assemble top panel to front and rear panels with wood screws.
- 12. SCrew in eye screws to hold axles.
- 13. Cut 1/8" steel rods (axles) to 4 3/8". Use emery paper to smooth rough ends.
- 14. Assemble axles and wheels.
- 15. Screw an eye screw into the front center chassis (See exploded view).
- 16. Screw a hook latch into the rear center chassis (See exploded view).
- 17. Paint the finished car as desired.



BOXCAR

REFRIGERATED CAR



Student Activity #5

Constructing a tank car for group #5

Tool list

- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill kit | 9. Hand saw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

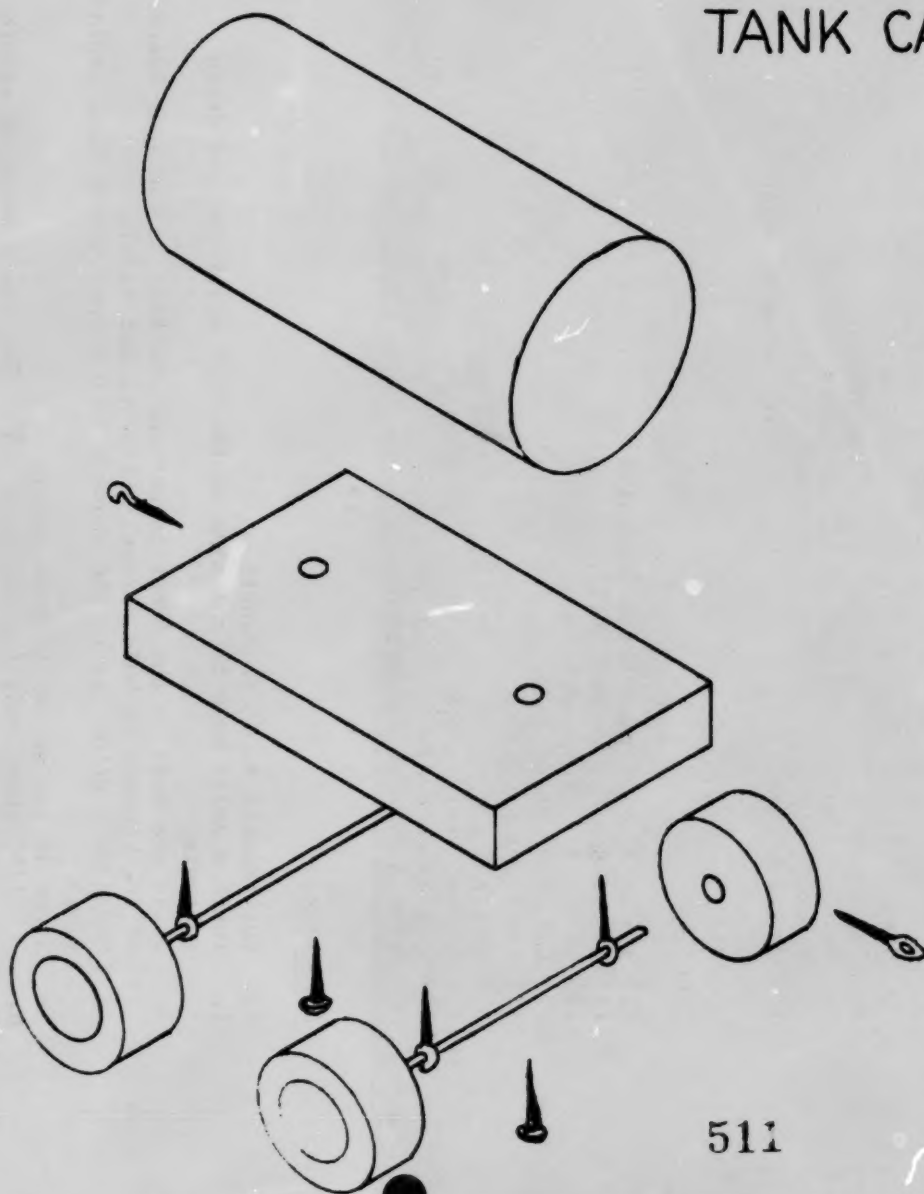
Material

- (1) 3/4" x 3" x 6" pine board (chassis)
- (1) 12 oz. soft drink can (full)
- (2) #8 x 1 1/2" FH wood screws
- (2) 1/8" x 5" steel rods
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) hook latch & eye
- paint & brushes as desired

Directions

- 1. Cut chassis to 5" in length.
- 2. Punch a small hole in the side of the soft drink can and drain contents.
- 3. Drill one hole in the front center and one hole in the rear center of the chassis to hold screws. (See exploded view).
- 4. Mount soft drink can to the chassis with 2 wood screws (see exploded view).
- 5. Screw in eye screws to hold axles.
- 6. Cut 1/8" steel rods (axles) to 4 3/8". Use emery paper to smooth rough ends.
- 7. Assemble axles and wheels.
- 8. Screw an eye screw into front center of the chassis. (See exploded view).
- 9. Screw a hook latch into the rear center of the chassis (see exploded view).
- 10. Paint the finished car as desired.

TANK CAR



511

Constructing a locomotive for group #6

General Directions: Construct these locomotion following the instruction below.

Tool List

- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill kit | 9. Hand saw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

Materials

- (1) 3/4" x 3 1/2" x 8" pine board (chassis)
- (1) 3/4" x 1 1/2" x 4" pine block (front panel)
- (1) 3/4" x 3" x 4" pine block (rear panel)
- (2) 3/4" x 3" x 8" pine board (side panel)
- (1) 3/4" x 3 1/2" pine board (top rear panel)
- (1) 3/4" x 3 1/2" x 4" pine board (top front panel)
- (16) #8 x 1 1/2" FH wood screws
- (2) 1/8" x 5" steel rods (axles)
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) hook latch
- paint & brushes as needed

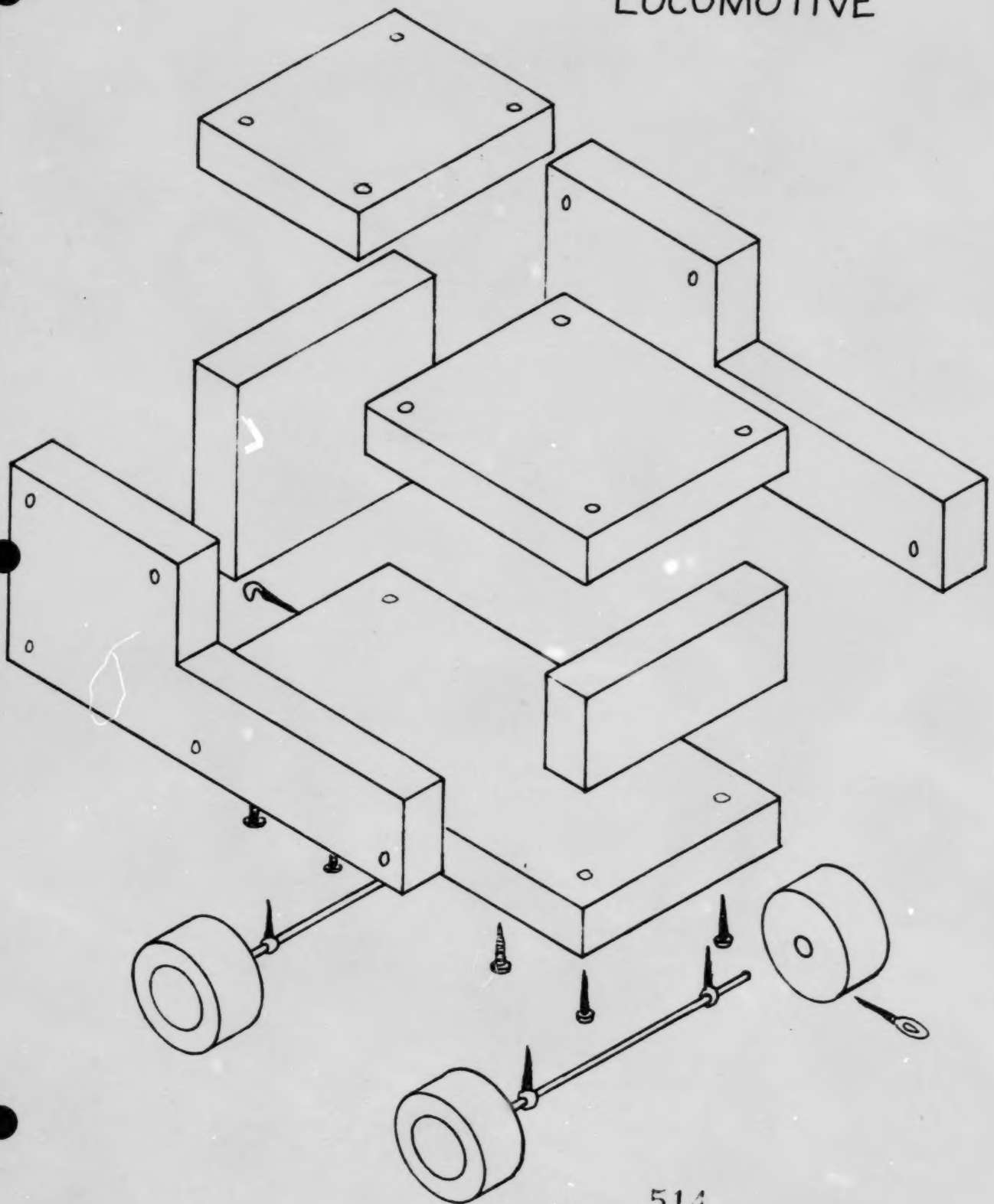
Directions for Construction

1. Cut chassis to 7" in length.
2. Cut front panel to 3 1/2" in length.
3. Cut rear panel to 3 1/2" in length.
4. Cut side panels to dimension shown in exploded view A.
5. Drill 2 holes in front of chassis to hold front panel. (First panel should be flush with chassis).
6. Drill 2 holes in rear of chassis to hold rear panels. (Rear panel should be flush with chassis).
7. Mount front and rear panels with wood screws.
8. Drill holes in sides of chassis to hold side panels. (See exploded view).
9. Mount side panels to chassis with wood screws.
10. Drill holes in top rear panel for mounting to rear panel and side panel. (See exploded view).
11. Mount top rear panel with wood screws.
12. Drill holes in top front panel for mounting to front panel and side panel. (See exploded view).
13. Screw in eye screws to hold axles.
14. Cut 1/8" steel rods (axles) to 4 3/8". Use emery paper to smooth rough edged.

LT 6.20

15. Assemble axles and wheels.
16. Screw a hook latch into the rear center of the chassis. (See exploded view).
17. Paint the finished locomotive as desired.

LOCOMOTIVE



Constructing a caboose for group #6

Directions: Construct three cabooses following the instructions below.

Tool List

- | | |
|----------------------|------------------------------|
| 1. Mitre box and saw | 8. Pencil |
| 2. 1/8" drill bit | 9. Hand saw clamp |
| 3. Hand drill | 10. Hack saw |
| 4. Try square | 11. Screwdriver |
| 5. Rule | 12. Scissors |
| 6. Hammer | 13. Awl |
| 7. Chisel | 14. Utility or exactor knife |

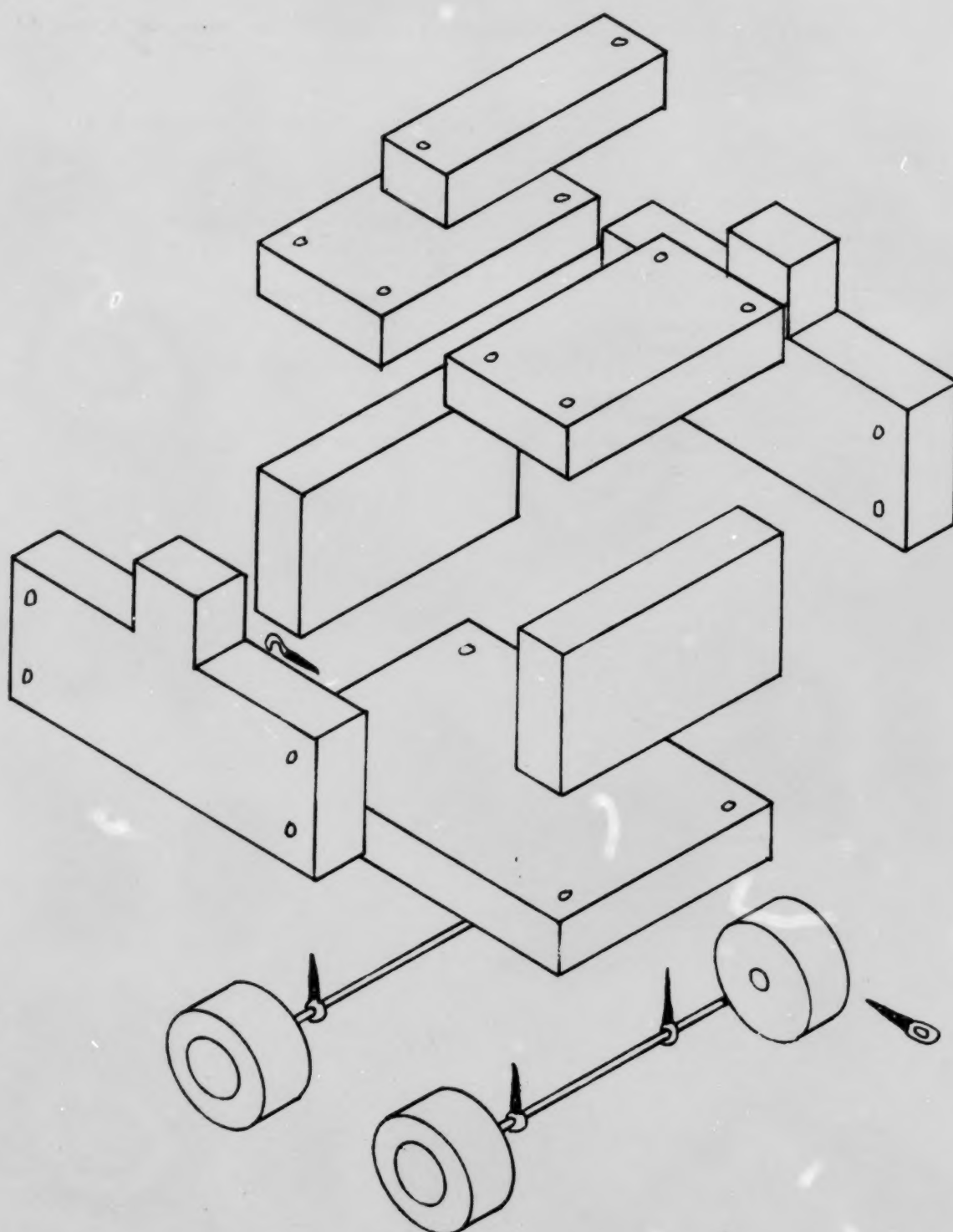
Materials

- (1) 3/4" x 3 1/2" x 6" pine boards (chassis)
- (2) 3/4" x 3 1/2" x 5" pine boards (side panels)
- (2) 3/4" x 3 1/2" x 2 1/2" pine blocks (front and rear panels)
- (2) 3/4" x 3 1/2" x 2" pine blocks (top panels)
- (1) 3/4" x 3 1/2" x 1" pine blocks (top roof panels)
- (20) #8 x 1 1/2" FH wood rods
- (2) 1/2" x 5" steel rods
- (4) small eye screws
- (4) wheels
- (1) 2" x 4" emery cloth
- (1) medium eye screw
- paint & brushes as needed

Directions for Construction

1. Cut chassis to 5" in length.
2. Cut side panels to dimensions in exploded view A.
3. Drill 2 holes in front of chassis for screws to hold front panel. (See exploded view).
4. Drill 2 holes in rear of chassis for screws to hold rear panel. (See exploded view).
5. Mount front and rear panels with wood screws.
6. Drill 2 holes on each side of chassis for screws to mount side panels. (See exploded view).
7. Mount side panels with wood screws.
8. Drill holes for screws to mount front and rear top panels. (See exploded view).
9. Mount front and rear top panels with wood screws.
10. Drill holes for screws to mount top roof panel. (See exploded view).
11. Mount top roof panel with wood screws.
Screw in eye screws to hold axles.
13. Cut 1/8" steel rods (axles) to 4 3/8". Use emery cloth to smooth rough ends.
14. Assemble axles and wheels.
15. Screw an eye screw into the front center of the chassis. (See exploded view).
16. Paint finished caboose as desired.

CABOOSE



SUGGESTED TEST

List 2 advantages of railroad transportation to highway transportation

1. _____
2. _____

List 2 disadvantages of railroad transportation to highway transportation

3. _____
4. _____

Match the freight car on the left with the freight that it would haul on the right

- _____ 5. Box car
- _____ 6. Gandola
- _____ 7. Open hopper
- _____ 8. Covered hopper
- _____ 9. Tank Car
- _____ 10. Flat Cat
- _____ 11. Piggy-back flat car
- _____ 12. Two-level rack car
- _____ 13. Refrigerated car
- _____ 14. Stock car
- _____ 15. Caboose

- A. Oil
- B. Boxes of fresh tomatoes
- C. Boxes of auto parts
- D. Cattle
- E. Steel girders
- F. Train crew
- G. Corn
- H. Loaded truck tractors
- I. Coal
- J. Lumber
- K. Automobiles

TEST ANSWERS

1. Can carry heavier amounts of freight.
2. Can carry a wider variety of freight
3. Shipments cannot be made direct to final destination
4. Slower
5. C
6. E
7. I
8. G
9. A
10. J
11. H
12. K
13. B
14. D
15. F

EQUIPMENT/SUPPLIES

I. Supplies

1. Transparencies
2. Masking tape
3. Materials and tools listed in Activity Sheet

II. Equipment

1. Overhead projector
2. Projection screen
3. Pointer

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Session:

LAND TRANSPORTATION

Title of Unit:

PIPELINES AND OTHER CONVEYANCES

DESCRIPTION OF UNIT

This unit contains the basic concept of pipeline transportation in the U. S. It gives an overview of pipelines and other conveyances.

UNIT OBJECTIVE

After completion of this unit the student will be familiar with pipeline transportation in the U. S. and will recognize other means of conveyance.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

A. Demonstrate a knowledge of pipelines by:

1. Matching twelve pipeline terms with their definitions;
2. Correctly reading a water meter each day for one week;
3. Calculating the amount of water used and the cost of water;
4. Correctly answering at least 80% of the questions on the test over this material.

B. Demonstrate a knowledge of other conveyances by:

1. Listing 5 means of people conveyances;
2. Listing 3 amusement and recreational conveyances.

OUTLINE OF CONTENT

I. Pipeline - a direct enclosed channel that provides a continuous flow of gas or liquid materials - after highway and railroad transportation it is the third most important means of land transportation in the U. S. economy

A. Types of Pipelines

1. Petroleum pipelines - a pipeline used to transport oil and oil based chemicals
2. Natural gas pipeline - a pipeline used to transport natural gas
3. Consumer liquid pipeline - a pipeline used to transport water and other consumer liquids
4. Sewers - a pipeline used to transport waste and sewage to treatment and/or disposal sites
5. Steam pipeline - a pipeline used to transport steam
6. Surface water control pipelines - a pipeline such as a storm sewer, irrigation and, etc.

B. Measuring and Control Devices - instruments built into the pipeline to regulate and control the flow of material through the pipeline

1. Valves - a device used to stop, restrict, or change direction of the material
2. Gauge - a device used to indicate the pressure or temperature of the material in the pipeline
3. Meter - a device used to measure the amount of material flowing through the pipeline
4. Safety valve - a valve that releases some of the material if the pressure becomes too high
5. Check valve - a valve that allows material to flow in only one direction

II. Other Conveyances

A. Construction vehicles

1. Cranes - used to hoist heavy building materials into place
2. Earth movers (bulldozers, back hoes, etc.) - used to move and level the earth for construction purposes

B. Assembly lines - used to move objects within a factory for the assembly of a finished product

1. Conveyor belt
2. Moving hooks

C. Farm implements - used to transport products

1. Tractor pulled carts and wagons
2. Harvestors

D. Pneumatic tubes - hollow tubes that use air pressure to move objects from one point to another

E. People Conveyors

1. elevators
2. escalators
3. moving sidewalks
4. cable cars
5. bicycles

F. Recreational and Amusement Conveyances

1. amusement park rides (ferris wheel, roller coaster, etc.)
2. go-carts
3. skateboards
4. roller skates

TEACHER ACTIVITIES

1. Provide student with learning module.
2. Discuss unit and performance objectives.
3. Discuss unit content and information:
 - Show T. M. #1 showing natural gas and oil pipelines in the U. S.;
 - Discuss the economic importance of pipeline to the economy;
 - Ask students to explain why pipelines are an inexpensive means of transportation;
 - Show T. M. #2 and explain water meters and how they are read.
4. Discuss the other means of conveyances listed.
 - Ask students to add other means of conveyances to this list.
5. Discuss the Student Activity #1 with the students.
 - Help students compare the letter requested in the activity.
6. Have students complete activity sheets.
7. Give test and evaluate results.

STUDENT ACTIVITIES

1. Read objectives.
2. Study information sheets.
3. Complete activity sheets.
4. Take tests.

LT 7.6

REFERENCES/RESOURCES

1. Information sheets.
2. Transparencies.

I. Pipelines

1. What is a pipeline?

A pipeline is a direct, enclosed channel that provides a continuous flow of gas or liquid materials - It is the third most important means of land transportation in the U. S. economy following highways and railroads

2. What are the different types of pipelines?

- Petroleum pipelines - transports oil and oil based chemicals
- Natural gas pipelines - transports natural gas
- Consumer liquid pipeline - transports water and other consumer liquids
- Sewers - transports waste and sewage to treatment and disposal sites
- Steam pipelines - transports hot steam
- Surface water pipelines - transports surface water (storm drains, irrigation canals, etc.)

3. What are measuring and control devices?

- Instruments built into the pipeline to regulate, control, and measure the flow of material through the pipeline.

4. What are some of the measuring and control devices found in the pipelines

- Meter - a device used to measure the amount of material flowing through a pipeline
- Safety valve - a valve that releases some of the material if the pressure becomes too high
- Check valve - a valve that allows material to flow in only one direction

II. Other Conveyances

A. Construction Vehicles

1. Cranes - used to hoist heavy building materials into place
2. Earth movers (bulldozers, back-hoes, etc.) used to move and level earth for construction

B. Assembly lines - used to move objects in a factory for assembly of a finished product

1. Conveyor belt
2. Moving hooks

C. Farm implements - used to transport farm products

1. Tractor pulled carts and wagons
2. Harvesters

D. Pneumatic tubes - hollow tubes that use air pressure to move objects from one point to another

LT 7.8

E. People conveyors.

1. Elevators
2. Escalators
3. Moving sidewalks
4. Cable cars
5. Bicycles

F. Recreational and Amusement Conveyances

1. Amusement rides (ferris wheel, roller coaster, etc.)
2. Go-carts
3. Skateboards
4. Roller skates

Student Activity #1

1. Contact your local suppliers of natural gas requesting information on the natural gas in your community (where it comes from, what company supplies it, etc.)
2. Write a letter to the company that supplies the natural gas to your area requesting the following information:
 - A. Where the gas field is located;
 - B. What pipeline transports the gas from the field to your area;
 - C. The amount of gas used by your community each year.
3. On a map of the U. S., trace the route of the pipeline from the gas field to your community.

Student Activity #2

1. Contact your local water company and request information on how to read a water meter and the cost of the water to the consumer.
2. Locate the water meter at your house and write down the reading on the meter indicating the date and time of the reading.
3. Read the meter at approximately the same time each day for one week.
4. Keep a log of the meter readings and the amount of water used each day.
5. At the end of the week take a final reading and determine the amount of water used in one week.
6. Using the cost of the water given to you by the water company, determine the cost of the water used in one week.

SUGGESTED CULMINATING ACTIVITY
FOR ALL OF LAND TRANSPORTATION

On available space, set up a land transportation activity including highways, railroads and pipeline systems.

Highways, of types described in Unit 5, should be painted on a plywood surface. Highway signs constructed by students in Unit 5 may be utilized as needed for traffic control. Highway vehicles described in Unit 5 should be used to transport people and materials over this system.

Model trains should be used for railroad transportation systems as described in Unit 6. As many cars as possible from Unit 6 should be utilized to transport people and materials over this system. Railroad and highway systems should intersect.

Plastic tubing, available from plumbing suppliers, should be used in conjunction with measuring and control devices described in Unit 7 to be construct a gravity fed pipeline system. This pipeline system is to be used in conjunction with the highway and railroad systems.

After completion of Unit 7 provide students with a list of solid and liquid materials. Student should utilize all three systems in routing assigned materials from one location to another. Students should also route transportation of people over the highway and railroad systems. Criteria for acceptable performance should be established by the teacher.

State objectives in each of the seven units on land transportation should be incorporated step-by-step into the culminating activity.

SUGGESTED TEST

A. Match the following pipeline terms with their definitions.

- | | |
|--|---------------------------------|
| _____ 1. The 3rd most important means of land transportation in the U. S. economy | A. Sewer |
| _____ 2. Transports water and other consumer liquids | B. Gauge |
| _____ 3. Storm drains, irrigation canals, etc. | C. Pipeline |
| _____ 4. Transports waste to treatment and disposal sites | D. Valve |
| _____ 5. Transports hot steam | E. Petroleum Pipeline |
| _____ 6. Transports oil and oil based chemicals | F. Consumer liquid Pipeline |
| _____ 7. Instrument built into pipelines to regulate, control and measure the flow of materials through a pipeline | G. Safety valve |
| _____ 8. Indicate pressure or temperature of material within a pipeline | H. Measuring and Control device |
| _____ 9. Releases some of the material if pressure in the pipeline becomes too high | I. Surface water Pipeline |
| _____ 10. Stops, restricts, or changes direction of the flow of material in a pipeline | J. Check valve |
| _____ 11. Measures the amount of material flowing through a pipeline | K. Steam Pipeline |
| _____ 12. Allows material to flow in only one direction within a pipeline. | L. Meter |

B. List 5 People Conveyors

13. _____

14. _____

15. _____

16. _____

17. _____

C. List 3 recreational and amusement conveyances

18. _____

19. _____

20. _____

TEST ANSWERS

- A. 1. C
2. F
3. I
4. A
5. K
6. E
7. H
8. B
9. G
10. D
11. L
12. J
- B. 13. Elevators
14. Escalators
15. Moving sidewalks
16. Cable cars
17. Bicycles (Students may list others)
- C. 18. Amusement rides
19. Go-carts
20. Skateboards (Students may list others)

EQUIPMENT/SUPPLIES

I. Supplies

1. Transparency masters
2. U. S. map
3. Marking pens

II. Equipment

1. Overhead projector
2. Projection screen
3. Pointer

TENNESSEE INDUSTRIAL ARTS CURRICULUM

U.S.O.E. Career Cluster:

TRANSPORTATION

Occupational Family:

LAND-DRIVING OCCUPATIONS

NATURE OF WORK

Nearly 2.5 million truck, bus, and taxi drivers moved passengers and goods over highways and city streets in 1976. Some drivers are behind the wheel practically all their working time. Others also spend part of their time loading and unloading goods, making pickups and deliveries, and collecting money.

Employment of long-distance and local truckdrivers is expected to expand through the mid 1980's as more and more freight is moved by trucks. Employment of busdrivers also is expected to increase as intercity passenger travel continues to grow and as cities expand their transit systems. Employment in other driving occupations is not expected to change much, but many new employees will be hired to replace those who retire, die, or stop working for other reasons.

Driving jobs offer excellent opportunities for persons who are not planning to attend college. The pay for most drivers is relatively high, and working conditions are fairly good.

Intercity Busdrivers:

In many smaller towns and cities, buses provide the only public transportation to other communities. In large cities, they are an alternative and, in many cases, provide more frequent service. Drivers move the buses to loading platforms where they take on passengers. They collect fares—tickets usually—as passengers board the buses and may use the buses' public address system to announce the destination, route, time of arrival, and other information concerning the trips.

JS LT 1

Local Truckdriver:

Local truckdrivers move goods from terminals and warehouses to factories, stores, and homes in the area. They are skilled drivers who can maneuver trucks into tight parking spaces, through narrow alleys, and up to loading platforms. The work of these drivers varies, depending on the product they transport. Produce truckers, on the one hand, pick up a loaded truck in the early morning and spend the rest of the day delivering the product to many different grocery stores. The day for a driver of a lumber truck, on the other hand, consist of several round trips between the lumber yard and one construction site or more.

Long-Distance Truckdrivers:

Long-distance truckdrivers drive the largest and most expensive equipment and receive the highest wages of all drivers. Their runs of long-distance truckdrivers vary widely. Some drivers have short "turnarounds". They deliver a load to a nearby city, pick up another loaded trailer, and drive it back to their home base the same day. Others are assigned runs that take an entire day to complete, and they remain away from home overnight. Often on these longer runs, drivers are assigned loads going to other cities rather than back to their home bases, and may continue to haul loads from city to city for as long as a week before returning home. Some companies use two drivers on very long runs. One drives while the other sleeps in a berth behind the cab. The "sleeper" runs may last for days, or even weeks at a time. Long-distance truckdrivers spend most of their working time behind the wheel.

Other Land-Driving Occupations:

Parking attendants park customers' cars and collect payment for the time they are left on the lot or in the garage. Attendants meet incoming cars and record their time of arrival on numbered claim checks. In lots where cars are parked bumper to bumper, parking attendants may ask customers when they expect to return so their cars will be more readily accessible when they need them. Some attendants may be required to perform routine maintenance jobs such as cleaning and sweeping the lot.

In practically all communities, taxicabs are an essential part of the public transportation system. Taxis offer individualized service. They pick up passengers at any location and drive them directly to their destination. Most taxicab drivers either work directly for a cab company or rent their cabs from a company. Others own their taxicabs and operate independently. Whether they are employees, renters, or owners, cab drivers have the same duties. Because cab drivers either rent their cabs or are paid on a commission basis, the more business they get, the higher their earnings. They know the different parts of the city will have potential customers at different times of the day. They may cruise the business district during rush hour and the shopping centers in the afternoon. Smart drivers also keep informed on where crowds are likely to gather.

SOURCES OF ADDITIONAL INFORMATION

American Trucking Association, Inc.
1616 P St. N.W.
Washington, D.C. 20036

National Parking Association
1101 17th St. N.W.
Washington, D.C. 20036

Occupational Outlook Handbook, 1978-79 Edition.

Dictionary of Occupational Titles, Fourth Edition, 1977.

Intercity bus companies, local transit system, local trucking companies
or the local office of the State Employment Service.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

U.S.O.E. Career Cluster:

TRANSPORTATION

Occupational Family:

LAND-SUPPORT OCCUPATIONS

NATURE OF WORK

So thoroughly have the automobile and truck become basic to our life that it is difficult to separate the many vocations created by their manufacture. One business in six out of the entire complex of businesses in this country is automotive; this includes only those dependent on the manufacture, distribution, servicing, and use of motor vehicles. One of every six people employed in the country works in a job related to cars and trucks.

The vehicle requires a large and skilled force to maintain it. Annual sales of automotive parts and labor amounts to more than the cost of all the cars sold in a year. Service technicians employed by dealers, perform a variety of jobs with a wide range of skills and training. Many mechanics become service managers, parts managers, or teachers.

Automobile Body Repairers:

Every day thousands of motor vehicles are damaged in traffic accidents. Although some are wrecked, most can be made to look and drive like new. Automobile body repairers are the workers who straighten bent frames, remove dents, and replace crumpled parts that are beyond repair. Usually, they can fix all types of vehicles, but most repairers work mainly on cars and small trucks. A few specialize in working on large trucks, buses, or tractor trailers.

Automobile Mechanics:

The ability to make a quick and accurate diagnosis is one of the mechanic's most valuable skills. It requires good reasoning ability as well as a thorough knowledge of automobiles. When mechanical or electrical troubles occur, mechanics first get a description of the symptoms from the owner or, if they work in a dealership, the service advisor who wrote the repair order. If the cause of the trouble is hard to find, the mechanic

may test drive the car or use testing equipment to locate the problem. Once the cause of the problem is found, mechanics make adjustments or repairs. If a part cannot be fixed, they replace it. Most automobile mechanics perform a variety of repairs.

Diesel Mechanics:

Diesel engines are stronger and thus last longer than gasoline engines. Because of their greater durability and efficiency, diesel engines are used to power most of the nation's heavy vehicles and equipment. Diesel mechanics repair and maintain diesel engines that power transportation equipment, such as heavy trucks, buses, boats, and locomotives; and construction equipment, such as bulldozers and cranes. They also service diesel farm tractors and a variety of other diesel-powered equipment. Before making repairs, diesel mechanics may use devices such as dynamometers to inspect and test engine components to determine why an engine is not operating properly. After locating the trouble, they repair or replace defective parts and make adjustments.

Farm Equipment Mechanics:

Farm equipment has grown enormously in size and variety in the past 25 years. Many farms have both diesel and gasoline tractors. In today's world of mechanized agriculture, few if any types of farming can be done economically without specialized machines. Almost every dealer employs farm equipment mechanics to do this work and to maintain and repair the smaller lawn and garden tractors. In addition, some mechanics assemble new implements and machinery for farm equipment dealers and wholesalers, and occasionally they must repair dented or torn sheet metal on the bodies of tractors or other machinery. Mechanics spend much of their time repairing and adjusting malfunctioning diesel and gas-powered tractors that have been brought to the shop. Mechanics also perform preventive maintenance.

Motorcycle Mechanics:

Today there are over five million motorcycles in the United States. Accompanying this rapid rise in the number of motorcycles has been a rapid increase in the number of motorcycle mechanics. Motorcycles, like automobiles, need periodic servicing to operate at peak efficiency. Spark plugs, ignition points, brakes, and many other parts frequently require adjustment or replacement. This routine servicing represents the major parts of the mechanics work. Most mechanics specialize in servicing only a few of the more than 30 brands of motorcycles and motor scooters. Mechanics may occasionally repair mini-bikes, go carts, snowmobiles, outboard motors, lawnmowers, and other equipment powered by small gasoline engines.

Truck and Bus Mechanics:

Commercial vehicles serve an important function in the nation's economy. Truck and bus mechanics perform the vital role of keeping these vehicles in good operating condition. They work on both diesel and gasoline engines. However, most mechanics usually repair only one type, because many of the engine components are different. Mechanics who work for organizations that maintain their own vehicles may spend much time doing preventive maintenance to assure safe operation, to prevent wear and damage to parts, and to reduce costly breakdowns. In many shops, mechanics do all kinds of repair work. In some large shops, however, mechanics specialize in one or two types of repair work. For heavy work, two mechanics may work as a team, or a mechanic may be assisted by an apprentice or helper.

SOURCES OF ADDITIONAL INFORMATION

Automotive Service Industry Association
230 North Michigan Avenue
Chicago, Ill. 60601

Automotive Service Councils, Inc.
188 Industrial Dr., Suite 112
Elmhurst, Ill. 60126

National Automobile Dealers Association
2000 K St. N.W.
Washington, D.C. 20006

National Farm and Power Equipment Dealers Association
10877 Watson Road
St. Louis, MO 63127

American Trucking Association, Inc.
1616 P St. N.W.
Washington, D.C. 20036

TRANSPORTATION

JOB STRUCTURE: LAND--DRIVING

JOB TITLE: Travel Agent

D.O.T. No.: 252 157 010

Major Job Function:

Plans itineraries, and arranges accommodations and other travel services for customers of travel agency.

Job Duties:

1. Converses with customer to determine destination, mode of transportation, travel dates, financial considerations, and accommodations required.
2. Plans or describes and sells itinerary package tour.
3. Gives customer brochures and publications concerning travel and containing information, such as local customs, points of interest, and special events occurring in various locations, or foreign country regulations, such as consular requirements, rate of monetary exchange, and currency limitations.
4. Computes cost of travel and accommodations, using calculating machine, carrier tariff books, and hotel rate books, or quotes cost of package tours.
5. Books customer or transportation carrier and makes hotel reservations, using telephone or teletypewriter.
6. Writes or obtains travel tickets for transportation or tour and collects payment.

JOB TITLE: Sales Representative, Motor
Vehicles and Supplies

D.O.T. No.: 273 357 022

Major Job Function:

Sells motor vehicles, such as automobiles, motorcycles, tractors, and trucks, and parts and supplies, such as batteries, tires, motors, chassis parts, tools, equipment, and lubricants, to dealers and service stations.

JS LT 7

Sales Representative Job Duties:

1. Confers with dealer and reviews sales records to determine number of vehicles to order.
2. Advises customers in methods of increasing sales volume, utilizing knowledge of sales promotion techniques.
3. Performs other duties as described under SALES REPRESENTATIVE.

JOB TITLE: Salesperson, Trailers & Motor
Homes

D.O.T. No.: 273 357 034

Major Job Function:

Sells travel and camping trailers, motor homes, and track campers to individuals.

Job Duties:

1. Determines customer's needs and exhibits vehicle of particular type or model.
2. Demonstrates use of equipment and furnishings.
3. May sell mobile homes, motorcycles, and snowmobiles.

JOB TITLE: Automobile Salesperson

D.O.T. No.: 275 353 010

Major Job Function:

Sells new or used automobiles on premises of automobile agency.

Job Duties:

1. Explains features and demonstrates operation of car in showroom or on road.
2. Suggests optional equipment for customer to purchase.
3. Computes and quotes sales price, including tax, trade-in allowance, license fee, and discount, and requirements for financing payment of car on credit.
4. Performs other duties as described under SALESPERSON.

JOB TITLE: Test Driver

D.O.T. No.: 806 281 050

Major Job Function:

Drives completed automobile, as vehicle comes from assembly line, on proving ground under simulated road conditions and observes performance to detect mechanical and structural defects.

Job Duties:

1. Examines car before road testing to insure that equipment, such as electrical wiring, hydraulic lines, and fan belts are installed as specified and verifies that car has been serviced with oil, gas, and water.
2. Drives car to simulate actual driving conditions.
3. Listens for rattles and excessive mechanical noise, and moves controls to test functioning of equipment, such as horn, heater, wipers, and power windows.
4. Drives car through water spray and visually inspects interior for leaks.
5. Writes inspection report on standardized form indicating defects or malfunctions.

JOB TITLE: Motorgrader Operator

D.O.T. No.: 850 663 022

Major Job Function:

Operates self-propelled grader to spread and level dirt, gravel, and stone, to grade specifications in construction and maintenance of earthwork structures, such as highways, streets, airports, dikes, and temporary roads.

Job Duties:

1. Drives grader and moves levers to regulate height and angle of grader blade, lower scarifier that loosens packed soil to permit grading, and to tilt front wheels of grader when making sharp turns.

Motorgrader Operator Job Duties (continued)

2. Drives grader in successive passes over working area, observing reference stakes or hand signals of assisting worker, to level surface to specified grade.
3. Feels lever and listens to sound of engine to determine depth of cut.

JOB TITLE: Asphalt-Paving Machine Operator D.O.T. No.: 853 603 010

Major Job Function:

Operates machines that spreads and levels hot-mix bituminous paving material on subgrade of highways and streets.

Job Duties:

1. Bolts extensions to screed to adjust width, using wrenches.
2. Lights burners to heat screed.
3. Starts engine and controls paving machine to push dump truck and maintain constant flow of asphalt into hopper.
4. Observes distribution of paving material along screed and controls direction of screed to eliminate voids at curbs and joints.
5. Turns valves to regulate temperature of asphalt flowing from hopper when asphalt begins to harden on screed.

JOB TITLE: Road-Roller Operator D.O.T. No.: 859 683 030

Major Job Function:

Drives heavy rolling machine to compact earth fills, subgrades, flexible base, and bituminous surface to grade specifications preparatory to construction of highways, streets, and runways.

Road-Roller Operator Job Duties:

1. Moves levers, depresses pedals, turns handwheels, and pushed throttle to control and guide machine.
2. Drives machine in successive overlapping passes over surface to be compacted.
3. Determines speed and direction of machine, based on knowledge of compressibility of material under changing temperatures, so that ridges are not formed by excessive pressure.

JOB TITLE: House Mover

D.O.T. No.: 869 261 010

Major Job Function:

Prepares buildings for moving from one site to another on trailer truck or rollers, determining most suitable technique based on knowledge of structures and moving-permit regulations.

Job Duties:

1. Observes size, shape, and position of building to determine placement on beams and route of travel.
2. Cuts large buildings into sections, using carpentry tools, to facilitate moving building, and to comply with permit regulations.
3. Breaks holes in foundation or removes underpinning, using steel cutters and carpentry tools.
4. Directs works in positioning timbers or steel beams under house.
5. Positions jacks under beams and raises house.
6. Rolls pneumatic-tired dollies under beams, lowers house onto dollies, and fastens dollies to beams, using chains.
7. Bolts crossbeam to supporting beams to provide tow-bar to move house.
8. Attaches winch-cable to crossbeams.
9. Directs TRACTOR TRAILER TRUCK DRIVER in moving building to new location and positioning it on new site.

JS LT 12

JOB TITLE: Dump-Truck Driver

D.O.T. No.: 902 683 010

Major Job Function:

Drives truck equipped with dump body to transport and dump loose materials, such as sand, gravel, crushed rock, coal, or bituminous paving materials.

Job Duties:

1. Pulls levers or turns crank to tilt body and dump contents.
2. Moves hand and foot controls to jerk truck forward and backward to loosen and dump material adhering to body.

JOB TITLE: Tank-Truck Driver

D.O.T. No.: 903 683 018

Major Job Function:

Drives tank truck to deliver gasoline, fuel, oil, lubricating oil, or liquified petroleum gas to customers.

Job Duties:

1. Drives truck into position to load at filling rack.
2. Opens valves and starts pumps to fill tank.
3. Reads gauges or meters and records quantity loaded.
4. Drives truck to customer's premises.
5. Connects hose to tank and opens valves.
6. Records amount delivered and issues ticket to customer.

JOB TITLE: Tractor-Trailer-Truck Driver

D.O.T. No.: 904 383 010

Major Job Function:

Drives gasoline or diesel-powered tractor-trailer combination, usually long distances, to transport and deliver products, livestock, or materials in liquid, loose, or packaged form.

Tractor-Trailer-Truck Driver Job Duties:

1. Drives truck to destination, applying knowledge of commercial driving regulations and skill in maneuvering vehicle in difficult situations, such as narrow passageways.
2. Inspects truck for defects before and after trips and submits report indicating truck conditions.
3. Maintains driver log according to I.C.C. regulations.

JOB TITLE: Log-Truck Driver

D.O.T. No.: 904 683 010

Major Job Function:

Drives truck equipped with long-tongued trailer, to haul logs from forest to mill or storage yard.

Job Duties:

1. Maneuvers truck into loading position according to signals from loading crew.
2. Fastens chain or cable binders around logs to secure load on trailer during transit.
3. May assist in loading and unloading logs, using crane hook or cant hook.

JOB TITLE: Milk Driver

D.O.T. No.: 905 483 010

Major Job Function:

Drives insulated tank truck to transport milk between farms, dairies, and commercial establishments.

Job Duties:

1. Examines milk to detect sediment or stale odor, and take sample for laboratory analysis.
2. Observes level gauge of storage tank and computes and records weight of milk in tank.

Milk Driver Job Duties (continued):

3. Connects hose and turns valves to pump milk into truck.
4. Washes truck.
5. May clear and sterilize tank.
6. May load and drive refrigerated van to haul cans of milk.

JOB TITLE: Garbage Collector Driver

D.O.T. No.: 905 663 010

Major Job Function:

Drives packer-type truck, dump truck, or truck equipped with hydraulic lifting device to collect garbage and trash, and transports load to disposal area.

Job Duties:

1. Records mileage and fuel consumption.

JOB TITLE: Heavy Truck Driver

D.O.T. No.: 905 663 014

Major Job Function:

Drives truck with capacity of more than three (3) tons, performing duties similar to those of TRUCK DRIVER LIGHT.

Job Duties:

1. When driving truck equipped for specific purposes, such as fighting fires, digging holes, and installing and repairing utility company lines, may be designated FIRE-TRUCK DRIVER.
2. When specializing in making deliveries may be designated DELIVERY TRUCK DRIVER, HEAVY.
3. May be designated according to type of truck driven as TRUCK DRIVER, FLATBED.

JOB TITLE: Van Driver

D.O.T. No.. 905 663 018

Major Job Function:

Loads furniture into van, drives truck to specified destination, and unloads furniture.

Job Duties:

1. Drives van to loading point and consults householder on furniture to be moved.
2. Gives directions to Van-driver Helper in moving articles to van.
3. Wraps furniture with blankets to prevent damage.
4. Wraps dishes and fragile items in packing paper and packs them into containers.
5. Loads truck, using dollies and handtruck, distributing weight evenly, forming compact load, and utilizing space.
6. Drives van to destination and unloads cargo.
7. Obtains customer's signature or collects payment for services.

JOB TITLE: Food-Service Driver

D.O.T. No.: 906 683 010

Major Job Function:

Drives truck to deliver refrigerated and electric-warming cabinets containing previously prepared meals to airports, and unloads cabinets into airplanes.

Job Duties:

1. Loads cabinets into truck and drives truck to flight field.
2. Maneuvers truck beneath airplane to be loaded and moves truck levers to elevate truck bed to level of airplane door.
3. Unloads cabinets into airplane and connects electrical cords of cabinets to electrical outlets of airplane.
4. Presents billing form to designated airline representative and collects receipt.
5. Loads empty cabinets onto truck and returns them to commissary kitchen.

JS LT 16

JOB TITLE: Liquid Fertilizer Servicer

D.O.T. No.: 906 683 014

Major Job Function:

Drives truck to deliver liquid fertilizer to field location and pumps fertilizer into tractor drawn applicator tank.

Job Duties:

1. Drives truck, containing supply tank filled with fertilizer, to area to be fertilized.
2. Couples hose from supply tank to feeder tank mounted on tractor.
3. Open valves on feed pipes to synchronize flow of fertilizer onto soil with speed of tractor, using pipe wrench.
4. Inspects tanks, hose, piping and couplings for leaks and replaces defective parts, using handtools.
5. Records quantity of fertilizer applied.

JOB TITLE: Light-Truck Driver

D.O.T. No.: 906 683 022

Major Job Function:

Drives truck with capacity under three (3) tons to transport materials in liquid or packaged form and personnel to and from specified destinations, such as railroad stations, plants, residences, offices, or within industrial yards.

Job Duties:

1. Verifies load against shipping papers.
2. Drives truck to destination, applying knowledge of commercial driving regulations and roads in area.
3. Prepares receipts for load picked up.
4. Collects payment for goods delivered and for delivery charges.
5. May be designated according to type of activity as CREW TRUCK DRIVER; INSECT SPRAYER, MAIL-TRUCK DRIVER; SERVICE-PARTS DRIVER; SPRINKLER-TRUCK DRIVER.

JOB TITLE: Driver Supervisor

D.O.T. No.: 909 137 010

Major Job Function:

Supervises and coordinates activities of TRACTOR-TRAILER TRUCK DRIVER and HEAVY TRUCK DRIVERS engaged in operating motor vehicles to haul materials for motor freight company or in off-highway haulage activities at industrial site.

Job Duties:

1. Performs duties as described under SUPERVISOR.

JOB TITLE: Hostler

D.O.T. No.: 909 663 010

Major Job Function:

Drives truck or tractors at vehicle parking or docking area to move, position, or park trucks or trailers.

Job Duties:

1. Drives trucks to and from service department and around area for motor freight transportation company.
2. Spots (positions) loaded and unloaded trailers at assigned dock space for unloading or loading, using tractor.
3. Connects loaded semitrailers to tractors for TRACTOR TRAILER TRUCK DRIVER.
4. May drive buses along municipal streets to deliver replacement vehicle to operator with disabled vehicle and be designate GARAGE BUS DRIVER.

JOB TITLE: Locomotive Engineer

D.O.T. No.: 910 363 014

Major Job Function:

Drives electric, diesel-electric, or gas-turbine-electric locomotive, interpreting train orders, train signals, and railroad rules and regulations, to transport passengers of freight.

Locomotive Engineer Job Duties:

1. Inspects locomotive before run to verify specified fuel, sand, water, and other supplies.
2. Synchronizes watch with that on PASSENGER CAR CONDUCTOR or ROAD FREIGHT CONDUCTOR and moves controls, such as throttle and air-brakes to drive locomotive.
3. Interprets train orders, train signals, and railroad rules and regulations to drive locomotive, following safety regulations and time schedule.
4. Calls out train signals to LOCOMOTIVE FIRER for verification of meaning to avoid errors in interpretation.
5. Confers with ROAD CONDUCTOR or traffic control center personnel to issue or receive information or instructions concerning stops, delays, or oncoming trains.
6. Observes track to detect obstructions.
7. Inspects locomotive after run to detect damaged or defective equipment.
8. Prepares reports to explain accidents, unscheduled stops, or delays.

JOB TITLE: Track-Moving-Machine Operator

D.O.T. No.: 910 663 010

Major Job Function:

Operates vehicle that automatically moves and lays track or rails to construct, repair, or maintain railroad tracks or mining car tracks.

Job Duties:

1. Pushes control to close grasping device on track or rail section, raise and move section to specified location.
2. Engages mechanism that lays track or rail to specified gage.

JOB TITLE: Street-Sweeper Operator

D.O.T. No.: 919 083 022

Major Job Function:

Drives sweeping machine that clears streets of trash and other accumulations.

Job Duties:

1. Fills water tank of machine from hydrant.
2. Moves controls to activate rotary brushes and water spray so that machine automatically picks up dust and trash from paved street and deposits it in dirt trap at rear of machine.
3. Pulls lever to dump refuse in piles at curb for removal.

JOB TITLE: Car Retail Deliverer

D.O.T. No.: 919 663 010

Major Job Function:

Delivers rental cars to customers, and services them prior to delivery.

Job Duties:

1. Washes windows and exterior of automobile, using water and other cleansing compounds and cloth.
2. Regulates tire pressure and adds gasoline and oil.
3. Adds water to battery and radiator.
4. Delivers automobile to customer at specified pickup point.
5. Collects rental payment and deposit from customer; and observes that customer reads and signs rental contract.

JOB TITLE: Escort-Vehicle Driver

D.O.T. No.: 919 663 022

Major Job Function:

Drives vehicle equipped with warning lights and signs to escort trucks hauling mobile homes on public thoroughfares.

Escort-Vehicle Driver Job Duties:

1. Precedes escort and maintains specified distance between pilot vehicle and escort to provide warning to other motorists and to clear traffic at locations.
2. Communicates by two-way radio with truck and other pilot vehicle drivers to coordinate changes in speed and route, emergencies, or traffic congestion.

JOB TITLE: Tow-Truck Operator

D.O.T. No.: 919 663 026

Major Job Function:

Drives tow-truck to move motor vehicles damaged by accident, stalled, or ticketed by police for traffic violation.

Job Duties:

1. Receives call or is dispatched to location by repair garage, automobile association, or police department by radio or telephone.
2. Attaches antisway bar to vehicle by means of cable, chains, or other grapping devices, and hoists one end of vehicle, using hand or powered winch, to tow vehicle to repair garage or to police department's impounding area.

JOB TITLE: Teamster

D.O.T. No.: 919 664 010

Major Job Function:

Drives one or more draft animals to pull materials, vehicles, or implements, such as logs, wagons, grading scrapers, fertilizer spreaders, plows, or scoops.

Job Duties:

1. Jiggles, pulls, and slackens reins, and gives oral commands to control movement team.
2. May be designated according to type of vehicle driven as CART DRIVER; MULE DRIVER or according to type of animals driven.

JOB TITLE: Driver

D.O.T. No.: 919 683 014

Major Job Function:

Drives completed automobile off assembly line to specified repair, shipping, or storage area.

Job Duties:

1. May test performance of parts, such as lights, horn, and windshield wipers.
2. May drive customer's vehicle to and from service area of repair shop and be designated CAR JOCKEY.

JOB TITLE: Tractor-Crane Operator

D.O.T. No.: 921 663 058

Major Job Function:

Operates diesel, gasoline, or electric-powered crane mounted on crawler treads to lift and move material and objects.

Job Duties:

1. Starts engine and drives crane to worksite, steering crane by moving levers and pressing pedals that control motion of crawler treads.
2. Pushes and pulls levers and presses pedals in response to hand signals to rotate crane on chassis and raise and lower crane boom and loadline.

JOB TITLE: Bulldozer Operator

D.O.T. No.:

Major Job Function:

Operates tractor equipped with concave blade attached across front to gauge out, level, and distribute earth and to push trees and rocks from land preparatory to constructing roads and buildings or planting crops or in mining, quarrying, and lumbering operations.

Bulldozer Operator Job Duties:

1. Fastens attachments to tractor with clevis or wedge-pin hitches.
2. Connects hydraulic hoses, belts, mechanical linkage, or power takeoff shaft to tractor to provide power to raise, lower, or tilt attachment.
3. Moves levers to control tool bars, carriers, and disks.
4. Moves levers and depresses pedals to maneuver tractor and raise, lower, and tilt attachment to clear right-of-way.
5. Feels lever and listens for stalling action of engine to estimate depth of cut.
6. Drives bulldozer in successive passes over terrain to raise or lower terrain to specified grade.

JOB TITLE: Concrete-Mixing-Truck Driver

D.O.T. No.:

Major Job Function:

Drives truck equipped with auxiliary concrete mixer to deliver concrete mix to job sites.

Job Duties:

1. Drives truck under loading hopper to receive sand, gravel, cement, and water and starts mixer.
2. Drives truck to location for unloading.
3. Moves levers on truck to release concrete down truck chute into wheelbarrow or other conveying container or directly into area to be poured with concrete.
4. Cleans truck after delivery to prevent concrete from hardening in mixer and on truck, using water hose and hoe.

TRANSPORTATION

JOB STRUCTURE: LAND--SUPPORT

JOB TITLE: Garage Supervisor

D.O.T. No.: 620 131 014

Major Job Function:

Supervises and coordinates activities of Automobile Mechanic engaged in repairing, adjusting, servicing, and storing motor vehicles in industrial or commercial establishment.

Job Duties:

1. Analyzes defective equipment to determine cause of trouble.
2. Inspects and drives repaired vehicles to verify repairs.
3. Trains workers in and demonstrates repair and maintenance of vehicles, using handtools, welding and grinding equipment.
4. Evaluates performance of workers.

JOB TITLE: Motorcycle Repair Shop Supervisor D.O.T. No.: 620 131 018

Major Job Function:

Supervises and coordinates activities of workers engaged in repairing or replacing engine, frame, electrical system, wheels, or other parts of motorcycle.

Job Duties:

1. Analyzes defects in motorcycle to determine feasibility of repairing or replacing worn or defective parts.
2. Trains workers in repair procedures and techniques.

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JOB TITLE: Automobile Mechanic

D.O.T. No.: 620 261 010

Major Job Function:

Repairs and overhauls automobiles, buses, trucks, and other automotive vehicles.

Job Duties:

1. Examines vehicle and discusses with customer or estimator.
2. Plans work procedure, using charts, technical manuals, and experience.
3. Removes unit, such as engine, transmission, or differential using wrenches and hoist.
4. Disassembles unit and inspects parts for wear, using micrometers, calipers and thickness gauges.
5. Overhauls or replaces carburetors, blowers, generators, distributors, starters, and pumps.
6. Rebuilds parts.
7. Rewires ignition system, lights, and instrument panel.
8. May be designated according to specialty.

JOB TITLE: Automobile Tester

D.O.T. No.: 620 261 014

Major Job Function:

Tests and examines automotive vehicles, such as automobiles, buses, and trucks, to determine repairs required.

Job Duties:

1. Starts engine of automotive vehicle and listens for sounds indicative of malfunctions.
2. Drives vehicle noting performance of parts, such as clutch, gears, and brakes.
3. Tests motor timing, cylinder compression, fuel consumption, wheel alignment, and steering using testing devices.

Automobile Tester Job Duties (continued):

4. Examines body and fenders of vehicle for scratches and dents.
5. Reports findings to supervisor or customer and recommends repairs required.

JOB TITLE: Tractor Mechanic

D.O.T. No.: 620 281 058

Major Job Function:

Diagnoses mechanical failures of and repairs tractors and tractor components according to manuals, factory specifications, and knowledge of engine performances, using handtools, power tools, and testing instruments.

Job Duties:

1. Attaches compression, ignition, and timing test instruments to certain parts of tractor, using clamps and handtools.
2. Starts engine dials and reads meters and gauges of testing equipment to diagnose engine malfunction.
3. Inspects parts for damage.
4. Replaces or repairs worn or damaged parts.

JOB TITLE: Tune Up Mechanic

D.O.T. No.: 620 281 066

Major Job Function:

Tunes automotive vehicle engines to insure efficient operation.

Job Duties:

1. Removes spark plugs, using socket wrench, and tests them, using spark-plug tester.
2. Cleans electrodes in sandblasting machine, sets spark gap with feeler gauge, and replaces or installs new plugs.
3. Inspects distributor breaker points for wear and pits, using feeler gauge, and replaces or resets points.

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JOB TITLE: Automobile-Mechanic Helper

D.O.T. No.: 620 684 014

Major Job Function:

Assist Automobile Mechanic in repairing automobiles, buses, trucks, and other automotive vehicles.

Job Duties:

1. Raises vehicle to specified level, using hydraulic jack.
2. Removes and disassembles unit such as engine, transmission, or differential, to be repaired, using handtools and power tools.
3. Cleans unit, using prescribed solvent.
4. Lubricates and washes vehicle.

JOB TITLE: Supervisor, Railroad Car Repair

D.O.T. No.: 622 131 010

Major Job Function:

Supervises and coordinates activities of workers engaged in inspecting, dismantling, welding, carpentering, painting, riveting, and testing parts, units, and damaged wood or steel sections of railway cars.

Job Duties:

1. May inspect damaged cars and prepare estimate of repair costs.
2. Performs duties as described under SUPERVISOR.

JOB TITLE: Locomotive Inspector

D.O.T. No.: 622 281 010

Major Job Function:

Inspects railroad locomotives in roundhouse or shop to determine extent of wear and needed repairs, using handtools and measuring instruments.

Locomotive Inspector Job Duties:

1. Examines firebox, journal boxes, and bearings to detect wear.
2. Taps parts, such as rods, wheels, and bolts with hammer or rawhide mallet and listens to sound to detect ruptures or cracks.
3. Measures wheel flanges with calipers and depth gauge to detect excessive wear of flat spots.

JOB TITLE: Railroad Wheels and Axle Inspector D.O.T. No.: 622 381 034

Major Job Function:

Inspects railway car axle and wheel assemblies to determine conformance to Federal and American Railroad Association specifications.

Job Duties:

1. Verifies diameter of wheel and journal seats on axle, using calipers and micrometers.
2. Measures space between wheels and from center of axle to each wheel, using needle-pointed space gauge, to verify conformance to specifications.
3. Observes hydraulic pressure-gauge indicator on wheel-pressing machine, as wheels are pressed on axle.

JOB TITLE: Car-Repairer Helper

D.O.T. No.: 622 684 014

Major Job Function:

Assists Car Repairer in repairing and rebuilding freight cars, tank cars, or locomotives, performing any combination of tasks listed below:

Job Duties:

1. Threads nuts and bolts and drills metal stock using hand taps, dies, and drill press.
2. Shears metal sheet and bar stock to specified dimensions.

Car-Repairer Helper Job Duties (continued):

3. Straightens metal parts, using hammer and sledge.
4. Bolts steel top frames to side frames of car, using power wrench.
5. Rolls axle and wheel assemblies into hydraulic wheel-dismounting machine.
6. Pull lever to position ram against end of axle and force wheel from wheel seat.

JOB TITLE: Supervisor, Engine-Repair

D.O.T. No.: 625 131 014

Major Job Function:

Supervises and coordinates activities of engine repairer, service engaged in repairing gasoline and diesel engines in service or production repair department.

Job Duties:

1. Analyzes data on service repair order or test rejection tag to determine nature of repair required.
2. May inspect and test repaired engines.
3. Performs other duties as described under SUPERVISOR.

JOB TITLE: Diesel Mechanic

D.O.T. No.: 625 281 010

Major Job Function:

Repairs and maintains diesel engines used to power engines used to power machines, such as buses, ships, trucks, railroad trains, electric generators, and construction machinery, using hardtools, precision-measuring instruments, and machine tools.

Diesel Mechanic Job Duties:

1. Diagnoses trouble, disassembles engines, and examines parts for defects and excessive wear.
2. Reconditions and replaces parts.
3. May weld and cut parts, using arc-welding and flame cutting equipment.

JOB TITLE: Diesel-Mechanic Helper

D.O.T. No.: 625 684 010

Major Job Function:

Assists Diesel Mechanic in overhauling and maintaining diesel motors used to operate trucks, generators, and other equipment.

Job Duties:

1. Disassembles motor and cleans parts. Obtains parts from stock and hand tools to mechanic.
2. Assists in reassembly, and cleans tools and working area.

JOB TITLE: Supervisor, Inspection and Testing D.O.T. No.: 721 131 014

Major Job Function:

Supervises and coordinates activities of workers engaged in inspecting and testing parts and subassemblies of electric motors and generators, such as armatures, stators, and field assemblies for conformance to specifications.

Job Duties:

1. Assigns workers to inspect parts for defects, such as improperly connected, broken, or cracked leads, surface defects on commutators, and for dimensional specifications of parts and subassemblies.
2. Designates type of test, method and procedure, and equipment to be used in testing parts and subassemblies.

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Supervisor, Inspection & Testing Job Duties (continued):

3. Analyzes test data to diagnose cause of malfunctions and schedules repair of products not meeting specifications.
4. Train workers in use of testing equipment.

JOB TITLE: Automotive-Generator-and-Starter D.O.T. No.: 721 281 010
Repairer

Major Job Function:

Tests, repairs, and rebuilds automotive generators and starters.

Job Duties:

1. Tests generator unit to ascertain amperage and voltage output, using voltmeter and ammeter.
2. disassembles unit and cleans brushes, bearings, shafts, and armatures in solvent and examines parts for wear or defects.
3. Refaces commutator using lathe.
4. Test starter spring tension, using testing device.
5. Replaces or repairs defective parts, and reinstalls generator in vehicle.
6. Adjusts fan belt tension and voltage output.

JOB TITLE: Supervisor, Automobile Body D.O.T. No.: 807 137 010
Repaire

Major Job Function:

Supervises and coordinates activities of workers engaged in repairing and painting damaged bodies and body parts of automotive vehicles.

Supervisor, Automobile Body Repairer Job Duties:

1. May examine damaged vehicle and estimate cost of repair.
2. Performs other duties as described under SUPERVISOR.

JOB TITLE: Truck-Body Builder

D.O.T. No.: 807 281 010

Major Job Function:

Constructs and repairs metal truck bodies and trailers according to specifications, using handtools and power tools.

Job Duties:

1. Lays out dimensions on metal stock, such as sheet metal and angle iron, using square, rule, and punch.
2. Fits and assembles components, using handtools and portable powered tools, such as drill, riveter, and welding apparatus.
3. Welds together body parts and braces.

JOB TITLE: Automobile-Body Repairer

D.O.T. No.: 807 381 010

Major Job Function:

Repairs damaged bodies and body parts of automotive vehicles, such as automobiles, buses, and light trucks according to repair manuals, using handtools and power tools.

Job Duties:

1. Examines damaged vehicles and estimates cost of repairs.
2. Remove upholstery, accessories, electrical and hydraulic window-and-seat operating equipment, and trim to gain access to vehicle body and fenders.
3. Positions dolly block against surface of dented area and beats opposite surface to remove dents, using hammer.
4. Fills depressions with solder or other plastic material.

Automobile-Body Repairer Job Duties (continued):

5. Refinishes repaired surface, using paint spray gun and sander.
6. Aims headlights, aligns wheels, and bleeds hydraulic brake system.

JOB TITLE: Frame Straightener

D.O.T. No.: 807 484 010

Major Job Function:

Straightens and aligns motorcycle frame according to specifications, using aligning table, jigs, gauges, jack, and handtools.

Job Duties:

1. Turns screws to adjust and set gauges and stops on jigs.
2. Positions and clamps frame in fixtures on aligning table.
3. Examines frame to ascertain degree of aligning required, using height and level gauges.
4. Realigns frame, using hammer, pry bar, and measures frame to verify alignment.

JOB TITLE: Automobile-Bumper Straightener

D.O.T. No.: 807 684 010

Major Job Function:

Repairs damaged automobile bumpers preparatory to replating.

Job Duties:

1. Selects specified make and model bumper from storage yard.
2. Positions bumper in hydraulic press and starts press to restore original shape to bumper, using templates to verify contours.
3. Removes smaller dents, using sledge hammer.

JOB TITLE: Track Repairer

D.O.T. No.: 910 682 010

Major Job Function:

Operates railroad track maintenance equipment, such as portable grinder, spike puller, spike driver, and tie adzer to grind ends of rails, remove old spikes, drive new spikes, and perform related maintenance.

Job Duties:

1. Operates single-or-multiple-head spike puller or pull old spikes from tie.
2. Raises rail, using hydraulic jack, to facilitate removal of old tie and installation of new tie.
3. Operates tie-adzing machine to cut portion of tie so that tie plate can be inserted to hold rail.
4. Drills holes through rails, tie plates and fishplates for insertion of bolts and spike, using power drill.
5. Operates spike driving machine to drive spike into tie and secure rail.

JOB TITLE: Track Oiler

D.O.T. No.: 910 687 026

Major Job Function:

Cleans out switches and greases rails around curves on streetcar tracks.

Job Duties:

1. Drives three-wheeled motorcycle, equipped with cleaning apparatus and lubricants, along track.
2. Pumps water from electric track-switch box with manually operated suction pump.
3. Sweeps dirt from track switch with broom.
4. Greases curves in rails with grease stick.
5. Throws rock salt over switches during cold weather to counteract freezing.

JOB TITLE: Tire-Service Supervisor

D.O.T. No.: 915 134 010

Major Job Function:

Supervises and coordinates activities of workers engaged in servicing and repairing automobile and truck tires and tubes.

Job Duties:

1. Examines damaged, defective, or flat tires to determine feasibility of repair and assigns workers to tasks.
2. Performs other duties as described under SUPERVISOR.

JOB TITLE: Parking-Lot Attendant

D.O.T. No.: 915 473 010

Major Job Function:

Parks automobiles for customers in parking lot or storage garage.

Job Duties:

1. Places numbered tag on windshield of automobile to be parked and hands customer similar tag to be used later in locating parked automobile.
2. Records time and drives automobile to parking space.
3. Patrols area to prevent thefts from parked automobiles.
4. Collect parking fee from customer.

JOB TITLE: Tire Repairer

D.O.T. No.: 915 684 010

Major Job Function:

Repairs damaged tires of automobiles, buses, trucks, and other automotive vehicles.

Tire Repairer Job Duties:

1. Raises vehicle using hydraulic jack, and unbolts wheel, using lug wrench.
2. Removes wheel from vehicle by hand or, when repairing giant tires of heavy equipment, by use of power hoist.
3. Locates puncture in tubeless tire by visual inspection or by immersing inflated tire in water bath and observing air bubbles emerging from puncture.
4. Seals puncture in tubeless tire by inserting adhesive material and expanding rubber plug into puncture, using handtools.
5. Separates tubed tire from wheel, using rubber mallet and metal bar.
6. Glues boot over rupture in tire casing, using rubber cement.
7. Inflates inner tube and immerses it in water to locate leak.

JOB TITLE: Lubrication Servicer

D.O.T. No.: 915 687 018

Major Job Function:

Lubricates moving parts of automobile vehicles, such as automobiles, buses, and trucks.

Job Duties:

1. Injects grease into units, such as springs, universal joints, and steering knuckles, using hand or compressed-air powered grease gun.
2. Inspects fluid level of steering gear, power steering reservoir, transmission, differential, rear axle housings, and shackles.
3. Checks air pressure of tires.
4. Lubricates moving parts with specified lubricants.
5. Drains oil from crankcase and refills crankcase with required amount of oil.
6. Sprays leaf springs with lubricant, using spray gun.

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JOB TITLE: Taxi Servicer

D.O.T. No.: 915 687 030

Major Job Function:

Services taxicab fleet and maintains terminal yard and office in orderly condition.

Job Duties:

1. Refuels and lubricates taxicabs.
2. Cleans parking area and removes rubbish.
3. Cleans offices and equipment.

JOB TITLE: Safety Truck Inspector

D.O.T. No.: 919 687 018

Major Job Function:

Inspects diesel and gasoline motortrucks to insure that trucks are equipped with accessories prescribed by law.

Job Duties:

1. Inspects truck for accessories, such as tools, chains, flares, and first aid kit.
2. Inspects air lines and electric circuits, and reports needed repairs.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

WATER

Title of Unit:

HISTORY, CURRENT TECHNOLOGY, AND FUTURE OF WATER TRANSPORTATION

DESCRIPTION OF UNIT

This unit will highlight the basic forms of water transportation including major developments in technological advances in water transportation. The materials in this unit are designed for 30 hours of instruction, but could readily be expanded to 45 or 90 hours by varying the activities.

UNIT OBJECTIVE

After completion of this unit the student will be able to arrange in chronological order the types of water transportation, be able to discuss orally the invention and development of various types of watercraft, and assist in designing and/or constructing a model of a historical type of watercraft or a newer development watercraft. This knowledge will also be evidenced by scoring 80% on unit test.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. Arrange in chronological order the types of watercraft developed by man.
2. Discuss orally the invention of watercraft propulsion including sails and oars, steam, diesel, and gas turbines.
3. Demonstrate the ability to construct (a) boat model(s) using different design techniques.
4. Discuss orally basic design requirements of watercraft.
5. Match basic watercraft terms with their definition.
6. Describe a minimum of 4 technical jobs/occupations related to water transportation.

OUTLINE OF CONTENT

- I. Introduction.
 - A. Water Transportation in Tennessee.
 - B. Glossary of Terms.
- II. Major Developments in Early Water Transportation to 1900.
 - A. Primitive Water Transportation.
 1. Inflated animal skins.
 2. Wickerwork or reeds covered by skins.
 3. Dugout logs.
 4. Frames covered with skins or tree bark.
 5. Flat boats.
 - B. Early Wooden Ships (TM #1)
 1. Early ships had only one mast--difficult to control and sail.
 2. Three masted ships were developed in the middle of the 15th Century (about 1450)--improved ease of sailing.
 3. Sails and oars were primary source of moving boats and ships until the invention of the steam engine.
 4. First submarine developed in 1775. (TM #2)

Do Student Activities #1, 2, 3, and 4.

 - C. Self-propelled Ships--Steam (wooden and iron). (TM #3)
 1. Robert Fulton made one of the first steam boats in 1807.
 2. Steam boats on Mississippi River by 1810.
 3. First steamboat across the Atlantic in 1840.
 4. Iron ships began appearing around the time of the Civil War (Monitor and Merrimack). More advances than any period up to that time.
 5. John Prock "father of iron shipbuilding" in 1870's.
 6. Both masts for sails, smoke stacks, and propellers were used in the 1880's.

7. Canals were being developed between rivers and lakes.

Do Student Activity #5.

III. Major Developments in Water Transportation Since 1900

A. World War I Had Great Influence of Development of Ships and Water Transportation. (TM #4)

1. Submarines were used a lot and anti-submarine devices and ships were used in World War I. (TM #5,6,7) (Information Sheet #7)
2. Many transport ships and military ships were built to transport materials and soldiers to Europe in World War I. Steering improved. (Information Sheet #8)
3. America emerged as a sea power.
4. TVA and other inland waterways developed.

B. World War II Ship Needs Speeded Advances in Shipbuilding

1. Hull and propulsion design improved to greatly increase speed of ships. (Information Sheet #3, 4) (TM #8,9, and 10)

Do Student Activity #6.

2. Many new special kinds of military and transport ships were designed, such as landing ship docks, net layers, PT boats, aircraft carriers, cruisers, destroyers, oilers, refrigerated food ships, troop transport ships, ships hauling spare parts, and cargo ships of all sizes and types.

C. Developments Since World War II

1. U. S. need for large amounts of petroleum caused large numbers of tankers to be built--some of world's largest ships.
2. Nuclear age appears with nuclear submarines and surface warships and first nuclear merchant ship in the S. S. S. Savannah.

Do Student Activity #7.

3. High speed hydrofoil ships were developed. (Information Sheet #5)
4. Surface effect ships (air cushion are now being used also--across English Channel). (Information Sheet #6)

Do Student Activities #8 and 9.

5. Water jet propulsion (refer to unit on Prime Movers)

D. Future of Water Transportation (Information Sheet #2)

Do Student Activity #10.

TEACHER ACTIVITIES

1. Provide students with module.
2. Make transparencies.
3. Discuss unit and specific objectives.
4. Given demonstration #1 and discuss the glossary to introduce unit.
(NOTE: This glossary is also used in the next two units--Inland Water and Ocean Transportation.)
5. Discuss information sheets and TM's as you go through the outline of material.
6. Discuss student activity sheets and assist students in performing the activities. (NOTE: These activities may be inserted into outline of content at various places at discretion of the instructor.)
7. Evaluate student activities.
8. Plan field trips and/or movies and "other" student activities, or invite speakers to school if field trips are difficult to accomplish.
9. Give tests and evaluate them.

STUDENT ACTIVITIES

1. Read objective sheets.
2. Study information sheets.
3. Complete activity sheets assigned.
4. Take field trips.
5. Take tests.

WATER TRANSPORTATION IN TENNESSEE



THE STATE SEAL

Between the outer lines of the seal are the words: The Great Seal of the State of Tennessee. The Roman numerals, XVI, signify the chronological order of admittance to the Union. A plow, a sheaf of wheat and a cotton stalk symbolize the importance of Agriculture, while the lower half shows a river boat attesting the importance of river traffic to Commerce, in the new State.

THE TENNESSEE RIVER

Water transportation has always been important to Tennessee and its people. It was vital in the settlement of the territory before it became a state and it is still important today. The Tennessee River and its tributaries carry vast amounts of cargo today on a waterway that has been improved by many dams and locks built by the Tennessee Valley Authority (TVA). Not only is the Tennessee River and its tributaries a vital link to the transportation of goods and materials within the State of Tennessee, but it also serves to connect Tennessee with the Gulf of Mexico via the Ohio and Mississippi Rivers.

Information Sheet #1

TERMS AND DEFINITIONS

When people enter a new occupation, they are faced with the task of learning the vocabulary of the trade. Until one does learn it, it is difficult to understand the meaning of what other people are saying. This glossary is provided to aid your transition from "boot" to "salt" in your understanding of water transportation. It is by no means complete, but it is comprehensive enough for you to understand what the older hands are talking about.

ABOARD: in or on a ship. Extended to use ashore, as aboard a naval station.

ADRIFT: loose from moorings and out of control. Applied to anything which is lost, out of hand, or left lying about.

AFT: toward the stern. Not as specific as abaft.

ANCHOR: A device that rests on the bottom of a river, lake, or ocean, that is fastened to a boat or ship to keep it from moving.

ANCHOR CABLE: the line, wire, or chain which attaches a vessel to its anchor.

ASTERN: directly behind a ship.

AYE AYE: reply to a command or order, meaning "I understand and will obey."

BARGE: (1) a blunt-ended, scow-type craft, usually nonself-propelled, used to haul supplies or garbage; (2) a type of motorboat assigned for the personal use of a flag officer.

BARNACLES: small shellfish which are found attached to the bottoms of vessels, pilings and other submerged structures.

BEARING: the direction of an object from an observer, measured in degrees clockwise from a reference point. True bearing is the angular difference between lines drawn from the observer to true north and to the object; magnetic bearing is the direction of the object measured on a magnetic compass; relative bearing is the angle between the ship's head and the object.

BELAY: (1) to secure a line to a fixed point; (2) order to disregard a previous order or to stop an action, as "Belay the last order," or "Belay the small talk."

BELOW: downward, beneath, or beyond something, as to lay below, below the flight deck, below the horizon.

BERTH: (1) bunk; (2) duty assignment; (3) mooring space assigned to a ship.

WT 1.8

BILLET: place or duty to which one is assigned.

BOAT: a small craft capable of being carried aboard a ship.

BOW: the forward end of a ship or boat.

BRIDGE: area in the superstructure from which a ship is operated. (See Conn)

BUOY: an anchored float used as an aid to navigation or to mark the location of an object.

BUOYANCY: The property of a liquid by which it puts an upward force on a body placed in it.

CHAIN LOCKER: space where anchor chain is stowed.

CHART: nautical counterpart of a road map, showing land configuration, water depths, and aids to navigation.

COLORS: (1) the national ensign; (2) the ceremony of raising and lowering the ensign.

CONN: station, usually on the bridge, from which a ship is controlled; the act of so controlling.

COURSE: a ship's desired direction of travel, not to be confused with heading, which is the direction in which the bow is pointing at any given instant.

DEAD AHEAD: directly ahead; a relative bearing of 000°. Dead astern is 180° relative.

DECK: horizontal planking or plating which divides a ship into layers.

DEEP SIX: to throw something overboard.

DIP: the act of lowering a flag part way down the staff as a salute to, or in reply to a salute from another ship.

DISPLACEMENT: the volume or weight of a fluid (as water) displaced by a floating body (as a ship) of equal weight.

DOCK: the term "dock" is commonly given to any pier or wharf, but strictly speaking it refers only to the space alongside a pier or in drydock.

DRIFT: the speed at which a ship is pushed off course by wind and current.

DRYDOCK: a dock from which the water may be removed for the purpose of

inspecting or working on a ship's bottom; it may be either floating or built into the shore.

EBB: ebb, ebb tide, and on the ebb all refer to a falling tide.

FLEET: an organization of ships, aircraft, marine forces and shore-based fleet activities, all under one commander, for the purpose of conducting major operations.

FORE: forward.

GALLEY: space where food is prepared. Never called a kitchen.

GENERAL QUARTERS: the condition of full readiness for battle.

HATCH: a square or rectangular access in a deck.

HEADING: the direction toward which the ship is pointing at any instant.

HELM: mechanical device used to turn the rudder; usually a wheel aboard ship, a lever in boats.

HELMSMAN: person who steers the ship by turning the helm. Also called steersman.

HULL: the shell or plating of a ship from keel to gunwale.

JOLLY ROGER: banner showing skull and crossbones, generally associated throughout history with pirates.

KEEL: the lowermost part of the ship. It runs the length of a ship and provides the ship with its strength. It could be compared to the backbone of a human being.

LASH: to secure an object by turns of line wire or chain.

LAUNCH: (1) to float a vessel off the ways in a building yard; (2) a powerboat, usually over 30 feet long.

LIBERTY: permission to be absent from a ship or station for a short time.

LIFE BUOY: a buoyant ring or other floating device designed to support a man in the water, except a lifejacket or lifebelt.

WT 1.10

LIFEJACKET: a buoyant jacket designed to support a man in the water; a life belt fits only around the waist.

LOOK ALIVE: admonishment meaning "be alert" or "move faster."

LOOKOUT: Person stationed topside as a formal watch who reports all objects sighted and sounds heard to the O.O.D.

MAIN DECK: the uppermost complete deck.

MOOR: (1) to anchor, using two anchors; (2) to make fast to a mooring buoy; (3) to make fast to a pier or other ship.

NEPTUNE: King Neptune; Neptunis rex; the Imperial Ruler of the Raging Main.

OVERBOARD: over the side.

PIER: structure extending from land out into the water to provide a mooring for vessels.

PILOTHOUSE: enclosure on the boat or ship that has the main steering controls.

POLLYWOG: a lowly person who has never crossed the equator.

PORT: to the left of the centerline when facing forward.

REEF: an underwater ledge rising abruptly from the ocean's floor.

RIGHTING MOMENT: a force that tends to restore a naval vessel to its upright position after it has been moved or tipped by wind or waves.

RUDDER: device attached to a ship's stern which controls the ship's direction of travel.

SCUTTLE: the act of deliberately sinking a vessel.

SEA: (1) the ocean in general; (2) the individual undulations of the surface are called waves, but as a whole they are referred to as seas. Also, a ship takes a big sea, not a wave, over the bow.

SEAWORTHY: a vessel capable of withstanding normal heavy weather.

SHIP: (1) any large seagoing vessel capable of extended independent operation; (2) to take on water unintentionally.

SHIPSHAPE: neat, clean, taut, in fine shape.

SICKBAY: shipboard space used as a hospital.

STARBOARD: direction to the right of the centerline as one faces forward.

SWAMP: the act of an open boat in filling with water taken over the side.

TOPSIDE: general term referring to weather decks.

WAKE: trail left by a vessel, or other object, moving through the water.

WEATHER DECK: any deck exposed to the elements.

FUTURE ON AND BENEATH THE SEA

Throughout history, technological progress has been made by day to day, step by step investment in new ideas, trial and research, and often with much error. As for viewing the future, we can only be guided by existing trends. While trends are generally clearly established, one problem is reading them correctly.

Dynamically supported craft (those that ride on top or near the top of the water) are improving in design and strength and should increase in their use in the future.

Planning hulls will remain basically the same for small pleasure boats (fishing and runabouts), but they are not suitable for bigger ships because they are not very good in rough seas.

Hydrofoil vessels are continuing to grow in size and use with maximum size probably at 100 tons. Speeds of 100 knots may soon be within reach.

Air cushion craft appear to hold the greatest promise for high-speed, oceangoing transport in larger vessels. The Maritime Commission has projected the possibility of a fleet of 5000 ton ships of the air cushion type capable of 100 knots in calm water and 40 to 50 knots in strong waves of 30 foot height.

For many years, man's curiosity about the ocean depths has led him toward the development of deep ocean vehicles that are capable of entering this mysterious and unknown world. Today less than 10% of the surface of the earth under the sea has been explored.

Multihull vessels, more often called catamarans, have been used and experimented with for centuries. Because of the greater stability of the multihull vessels, they are very popular in sail boat design. They are also used greatly in special ocean vessels in research and rescue.

Most of the world's cargo moves, and will continue to move on heavy commerce; iron ore, oil, fertilizers, and automobiles must be transported together with great amounts of different merchandise and bulk cargoes. The most economical means of transporting these goods is still with the big ships. Oil will continue to travel in super tankers; dry cargoes and other selected cargoes travel in faster container ships.

As long as warships are required, the aircraft carriers will continue to be the most complex of all displacement vessels. Other smaller naval fighting ships will continue to be required.

The day is not foreseeable when man will be able to do without ships--and ships as we traditionally know them. The technology of building them, propelling them, and servicing them will change and improve. Ships will still be very recognizable, floating buoyant or submersible mobile vessels carrying people and their cargoes.

Information Sheet #3

MODERN SHIP DESIGN

There are many complicated mathematical problems that have to be solved in modern ship design. Large ships are often like icebergs with more ship under the water than shows above.

As the larger ships move through the water they have to push the water aside. TM #1 Ship designers have discovered that the double wedge hull works well for both large ships and small pleasure boats. The next time you visit a marine dealer, see if you can determine the double wedge in a boat.

TM #3 The shape of submarines has changed recently to increase their speed. The Navy submarines have a shape now that is similar to the big whales.

TM#2. A new construction technique in ship design is to construct ships with hulls made of flat pieces of metal plates welded together at distinct angles. This eliminates the expensive process of forming each plate to blend into one smooth curved surface on the outside of the ship.

MULTIHULL VESSELS

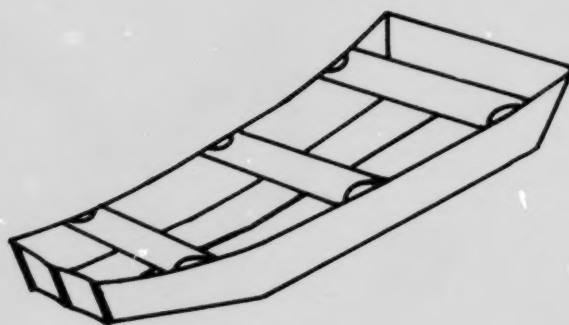
Multihull (more than one hull) vessels have been used for hundreds of years. Vessels with two hulls, called catamarans; and vessels with three hulls, called trimarans, are the most popular versions. The biggest advantage of more than one hull fastened together with a sizable deck has greater stability in water.

Some of the catamaran and trimaran hull designs are used in small fishing boats and especially in sailboats today. Multihull vessels are used in larger ocean going vessels such as ocean research vessels, submarine rescue ships, salvage ships, etc., where the protected space between the hulls provide s a calm place for working in the water.

CATAMARAN
SAIL BOAT

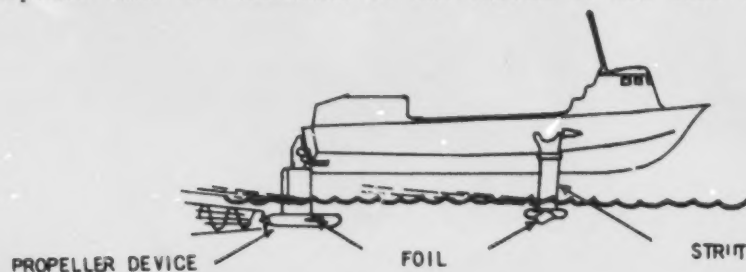


TRIMARAN
FISHING BOAT



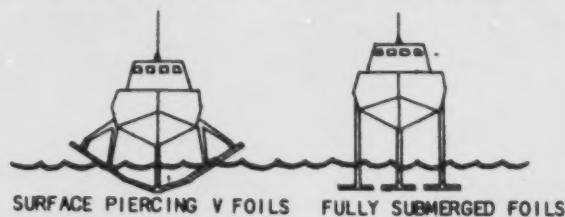
HYDROFOILS

Another recent development in smaller boat design has been the design and use of hydrofoils. Hydrofoils are similar to wings of an airplane that are fastened to the bottom of the boat by support struts.



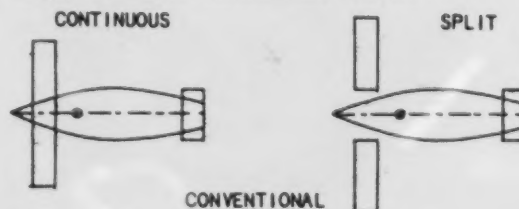
A boat equipped with hydrofoils starts from rest with the hull in the water like all other boats and the foils are under the water. As the boat increases in speed the weight of the boat gradually shifts to the foils and the hull is lifted out of the water. The boat is then turned like an airplane by turning a rudder or tilting foils.

Some foils stick out of the water (surface-piercing) and some stay under the water (submerged) while the boat is running on the foils.



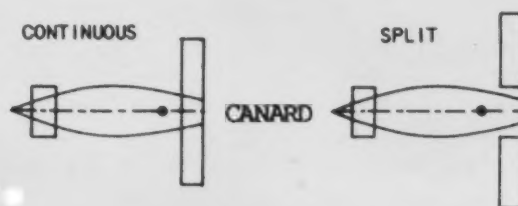
The surface-piercing foils are the simplest and strongest but they are not as energy efficient as the submerged foils. The foils also may be continuous or split into parts.

The size and placement of the foils on a boat depend on where the center of gravity of the boat is located. If the weight is concentrated near the front, conventional foils are used.

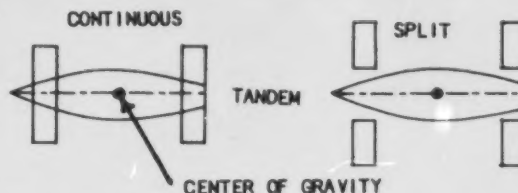


If the weight is concentrated near the back of the boat, Canard type foils are used. It is basically the reverse of the conventional

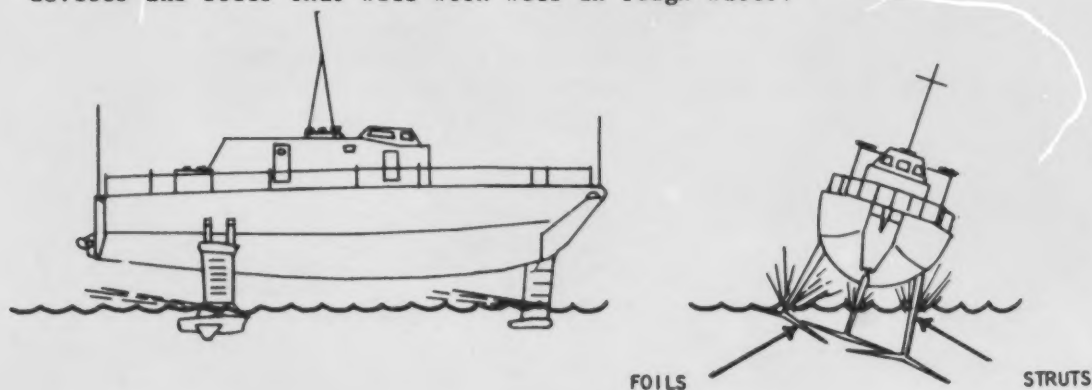
foil system. You see the large foil is located under the greatest weight.



If the weight of the boat is concentrated near the center of the boat, tandem foils of equal size are placed under the front and back of the boat.



The biggest problems with foils is developing good controlling devices and foils that will work well in rough water.

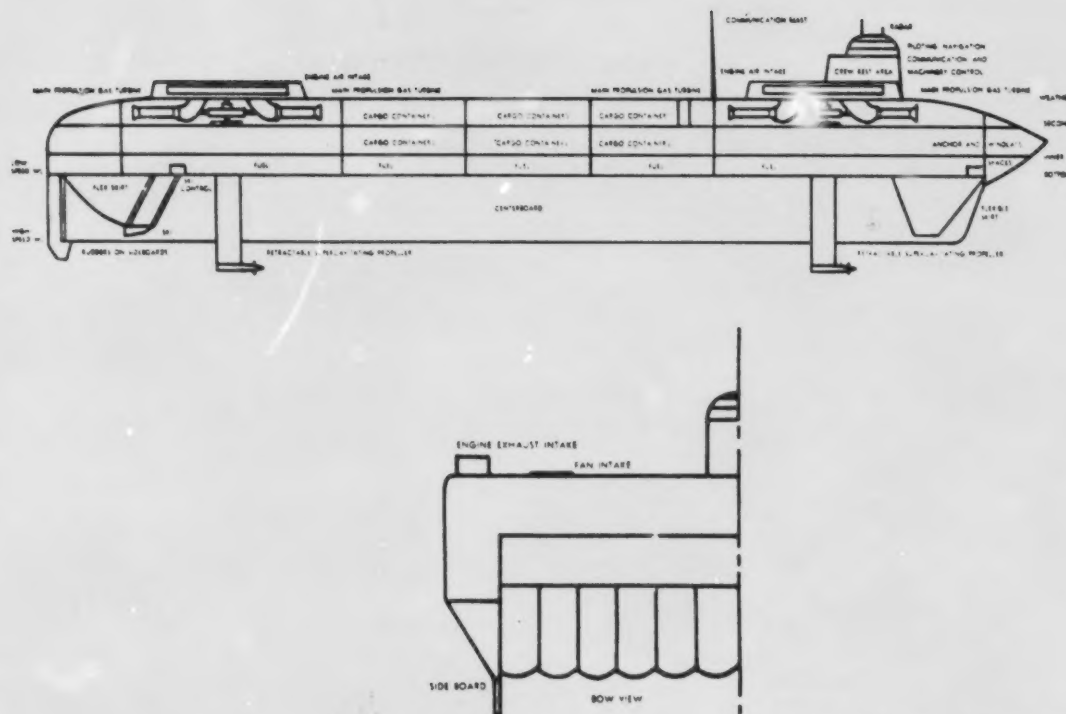


The above illustrations show two views of a hydrofoil boat in action.

AIR CUSHION CRAFT

Many different designs of air cushion craft have been developed over the recent years. The most successful design developed was in 1958 by Hovercraft Corporation in England.

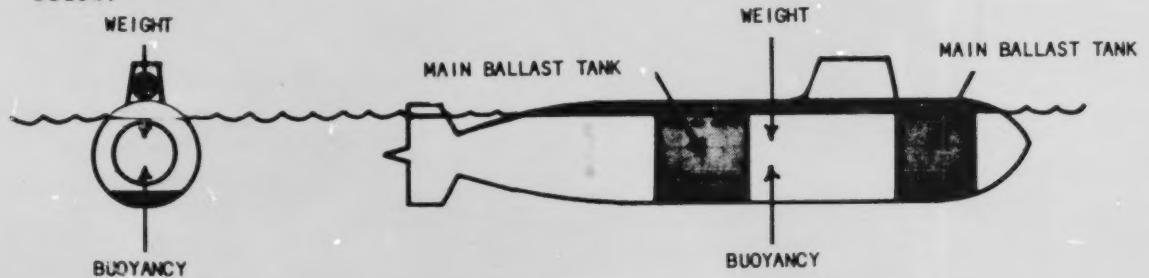
The principle of the air cushion craft is quite simple. Large fans blow air into an enclosed space under the flat bottom of the craft. The outside edge is sealed off by a rigid rubber type curtain to keep the air under the craft. The fans create enough air pressure under the craft to lift it off the water. The forward motion of the craft is then provided by separate engines driving air propellers or propellers that stick down into the water on struts.



Courtesy of U.S. Maritime Administration

HOW A SUBMARINE WORKS

The design of a submarine could be compared to that of two cylinders, both closed at both ends. One cylinder is slightly smaller than the other and is placed inside the larger one as in the figure below.



The space between the two cylinders is called a ballast tank. When the ballast tank is filled with air the submarine floats on top of the water. As the ballast tank is filled with water the submarine will sink deeper into the water until the tank is full of water and the submarine is completely under water. The reason for this is that trapped air increases buoyancy of the submarine to make it float and adding water increases the weight and reduces the buoyancy to make the submarine sink.

This process of sinking (submerging) and surfacing is shown in
TM #

Submarines are used for deep ocean research as well as by the Navy.

Information Sheet #8

STEERING A SHIP

Small boats with outboard and inboard engines are turned by turning the motor or propelling device. Large ships and sail boats are turned by means of a rudder.

Rudders consist of two basic parts: the float part or blade, against which the water pressure acts; and the shaft or stock which transmits the motion of the steering gear to the blade.

There are three basic types of rudders--unbalanced, semibalanced, and balanced. TM #5. These differences are caused by the differences in the position of the shaft in relation to the center of the rudder blade.

Smaller boats can use unbalanced rudders, but as the size of the ship increases the type of rudder should move to semibalanced and to balanced rudders for very large ships such as tankers.

CHARACTERISTICS OF VARIOUS ENGINES

There are five primary types of engines that are used to power ships at the present time. They are the steam turbine, gas turbine, diesel, Otto (gasoline), and the turbojet (aircraft type). The horsepower range of each type is generally as follows:

<u>Engine Type</u>	<u>Horsepower</u>
Otto (gasoline)	150 to 500
Turbojet (aircraft type)	up to 3500
Diesel	250 to 25,000
Gas turbine	500 to 40,000
Steam turbine	35,000 to 100,000+

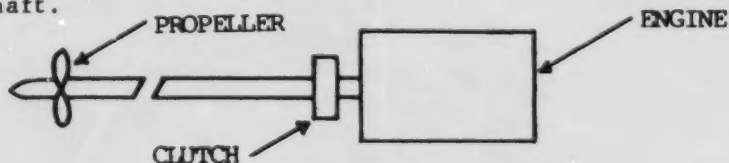
Selection of engine to use depends, of course, on the size of the ship but also consideration has to be given to speed, and cruising range of the ship. The very large ships need to be powered by steam but the smaller ones may use any of the others depending of the purpose for which the ship was designed. The turbojet and gas turbine engines can produce higher speeds than diesel and gasoline engines.

Other factors to consider are expected engine life and hours between engine overhauls.

<u>Engine Type</u>	<u>Expected Life in hours</u>	<u>Hours Between Overhauls</u>
Turbojet	5,000	1,000
Otto	20,000	1,500
Gas Turbine	20,000	1,500
Diesel	40,000	2,000
Steam Turbine	40,000	6,500

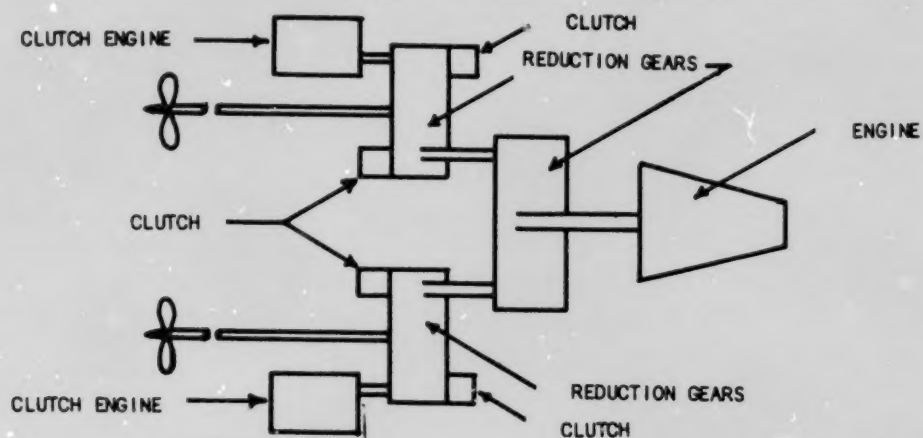
There are a variety of arrangements of transmitting power from the engine of the ship to the propelling device. Common propelling devices are propellers, water jets, and fans.

Engines on smaller crafts are connected directly to the propellers by a straight shaft.



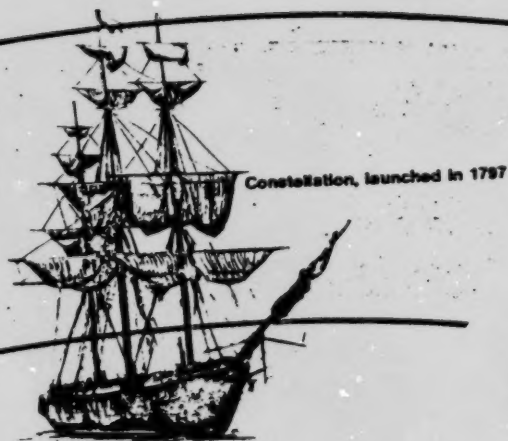
Others have a lot of gears like a transmission in an automobile. Because some engines run at such high speeds, gearing is used to slow

down the rotation. On ships this gearing is called reduction gears.



Additional information on power is contained in the unit on prime movers.

Early Ship Transportation

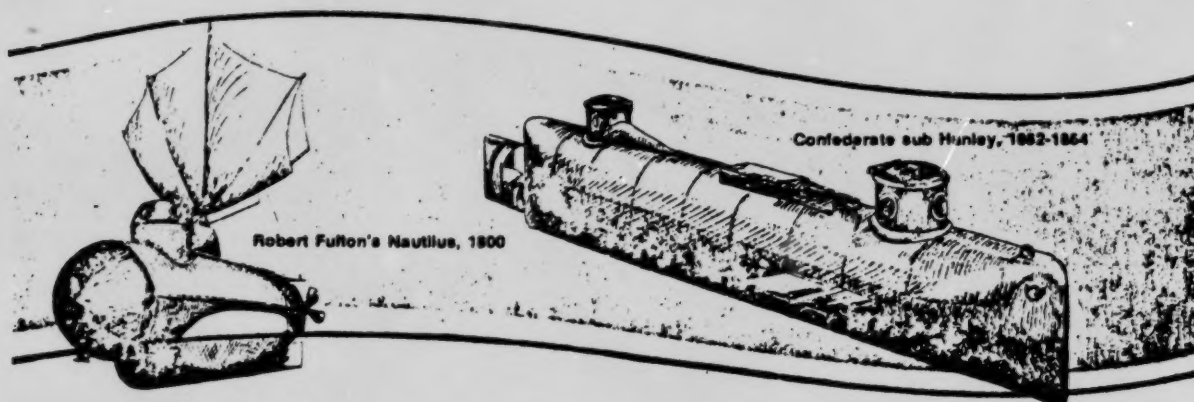


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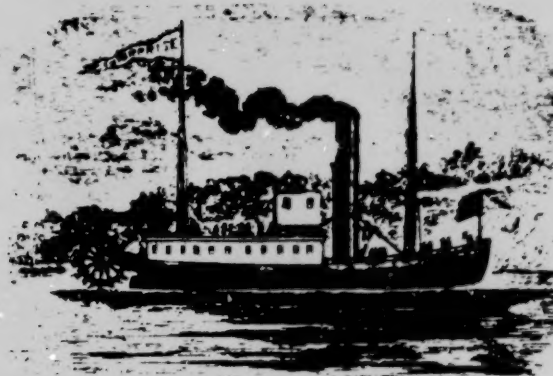
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SUBMARINE

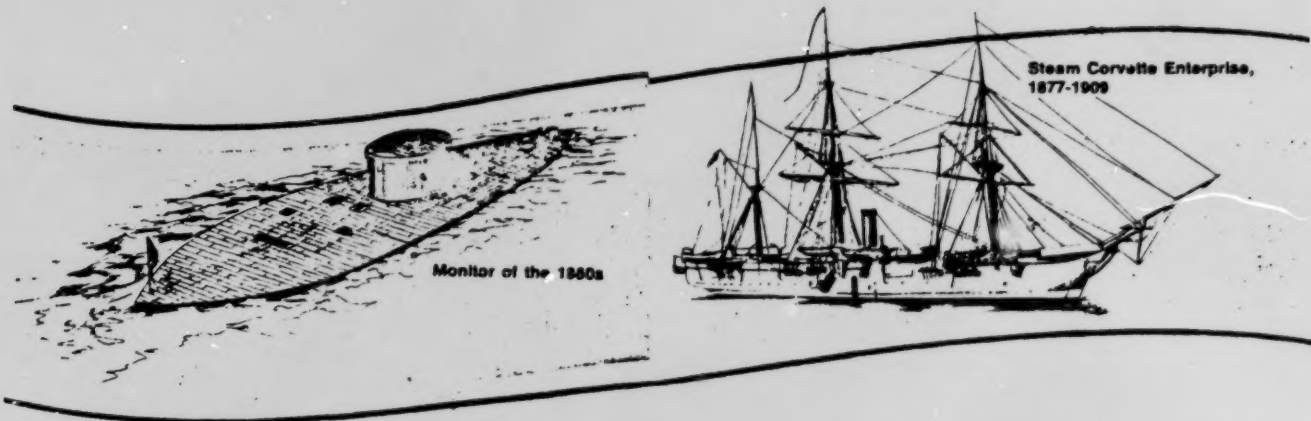
Cutaway of David Bushnell's
Turtle, 1775



SELF-PROPELLED SHIPS



The Enterprise, of forty-five tons, built at Brownsville on the Monongahela in 1814, was the first steamboat to ascend the Mississippi and Ohio Rivers. Under command of Henry M. Shreve, she carried munitions to New Orleans in December 1814. Vessel and captain were there commandeered by General Andrew Jackson for varied duties in preparation for the Battle of New Orleans, which occurred 8 January 1815



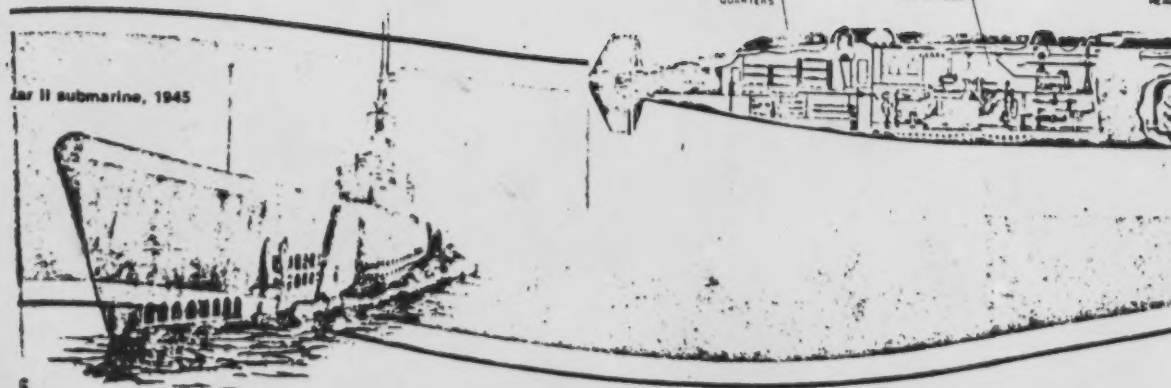
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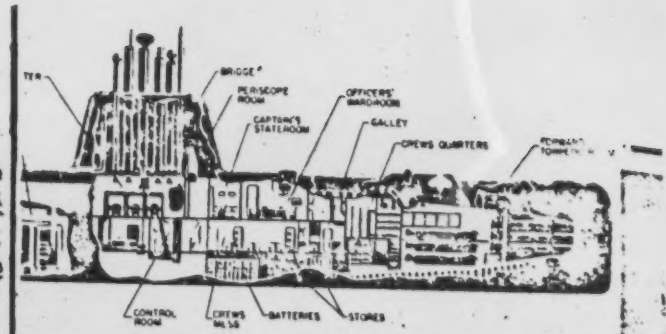
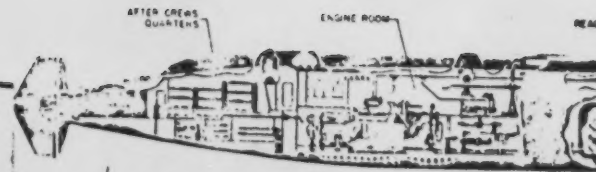


The growth and decline of American merchant marine prior to World War I.

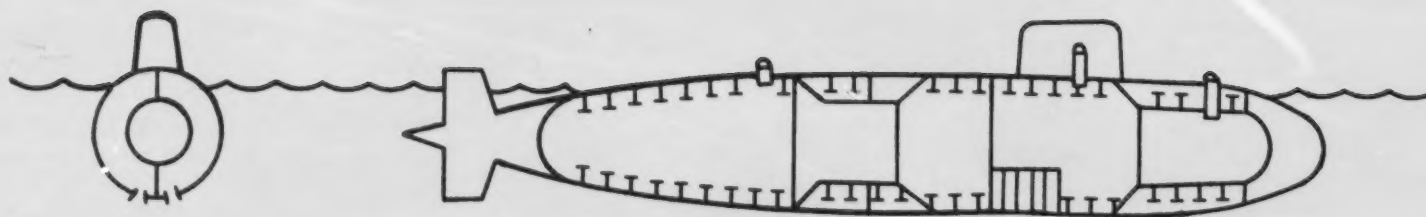
SUBMARINE



War II submarine, 1945



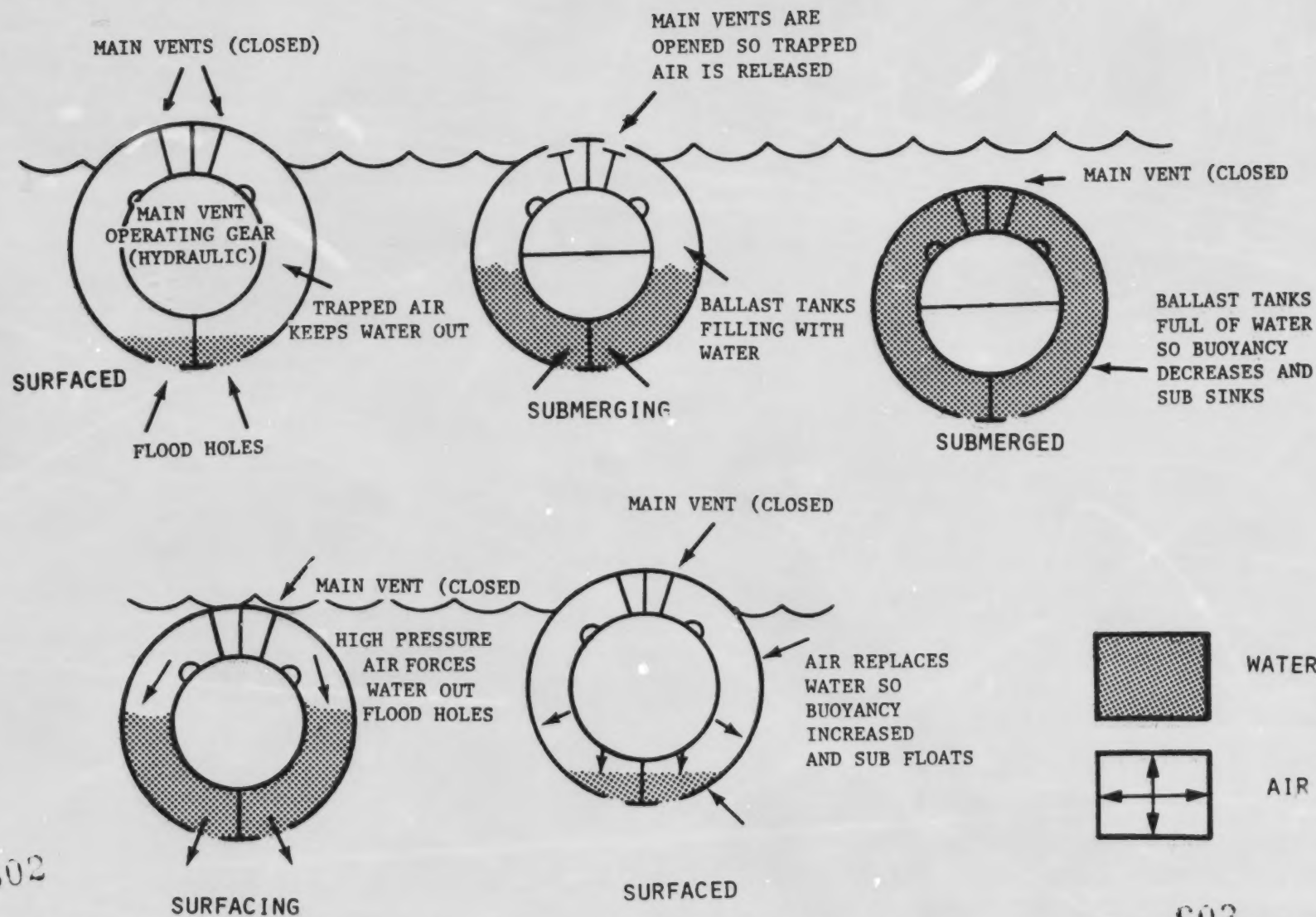
Trident, designed to be world's most modern sub



SHAPE OF A MODERN SUBMARINE

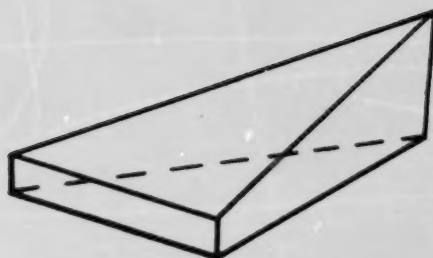
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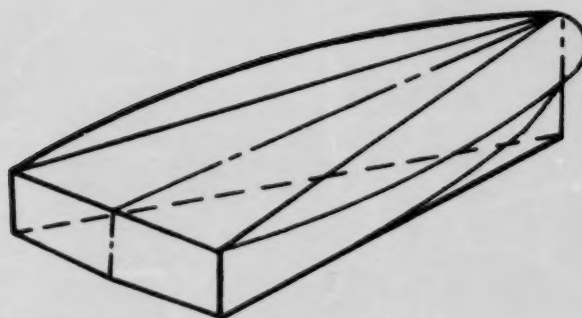


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HULL TYPES



DOUBLE WEDGE

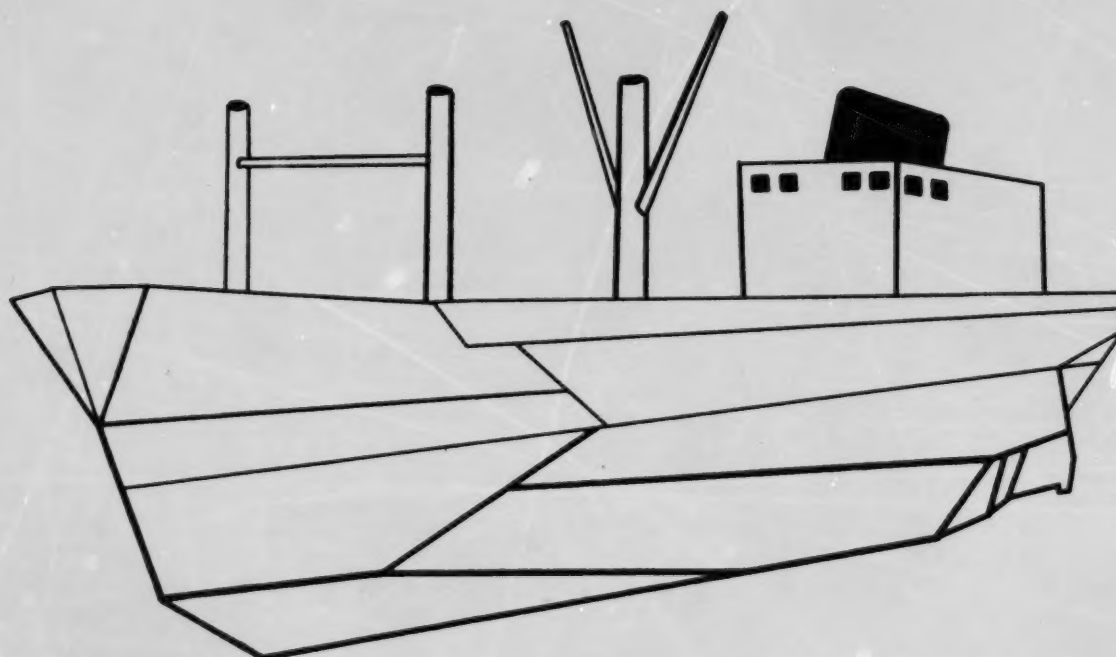
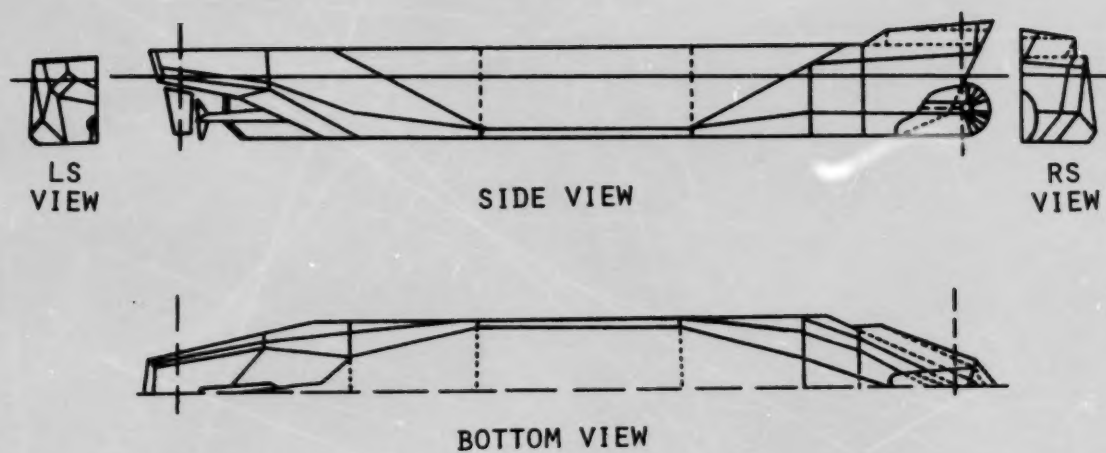


SMALL PLEASURE BOAT

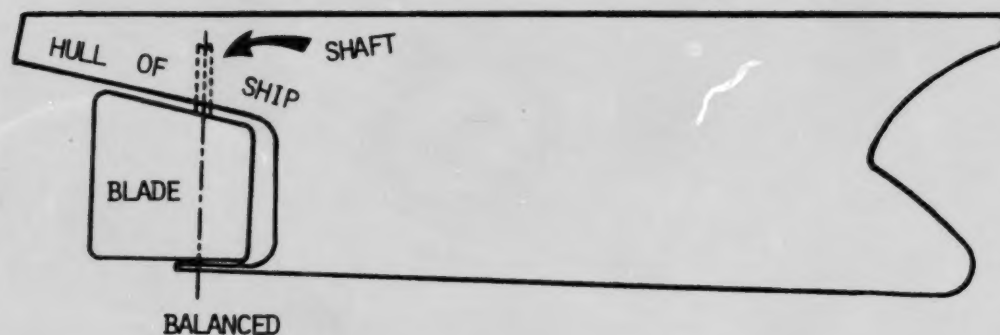
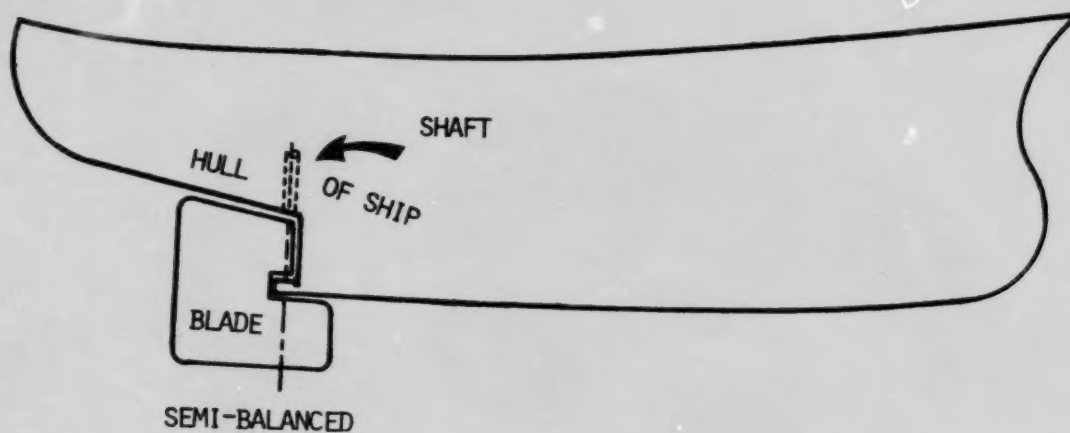
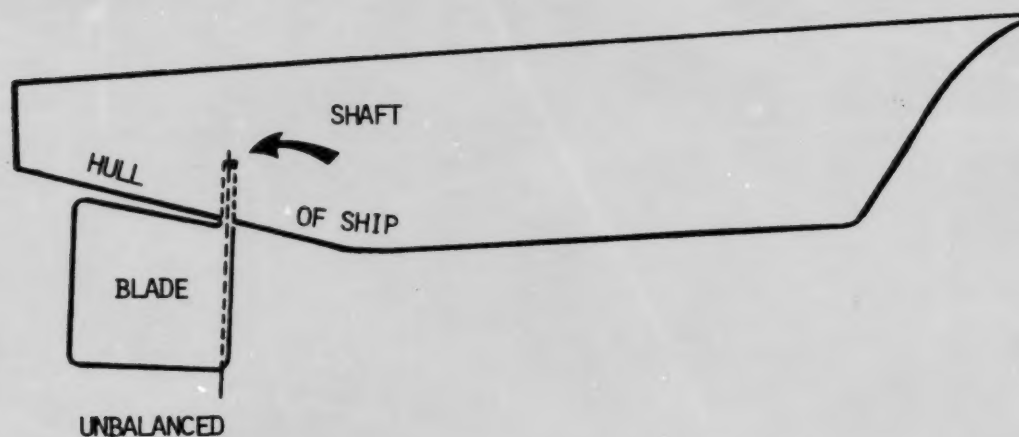


LARGE SHIP

FLAT PLATE HULL DESIGN



RUDDER TYPES



Demonstration #1

HISTORY AND DEVELOPMENT OF WATER TRANSPORTATION

Use Demonstration #1 to introduce unit and create interest.

Objective:

When you finish this activity the students will have an understanding of how and why heavy ships and boats can float in water and not tip over. The students will also have an understanding of the meaning of bouyancy, displacement, and righting moment.

1. Water is heavy (i.e., have you ever carried a pail of water?).
2. Water weighs 62.5 lbs. per cubic foot (A gallon weighs 8.2 lbs.).
3. Principle--Because water is a liquid, it seeks its own level and will push up on things placed in the water with a force equal to the volume (cubic feet) of water displaced (pushed aside) by the object or ship in the water.

Materials:

1. 55 gal. drum sawn in half lengthwise or equivalent container to hold water.
2. Wooden board 6" wide 1" thick, 12" to 18" long with 1/2" holes drilled along one edge every 2 inches.
3. Enough 1/2" bolts and nuts to fill holes in board.

Procedure:

1. Procure drum or other container and fill with at least 8" of water. (A wooden box lined with plastic will work.)
2. Weigh a cubic foot of water.
3. Select a board, weigh it, and place it in water and attempt to float it (narrow edge up). It won't--explain bouyancy.
4. Add nuts and bolts to bottom edge of board until it floats on edge in water and doesn't sink. Explain displacement.
5. Attempt to float board on flat side or with edge up that contains nuts and bolts. Explain righting moment.

Terms:

1. Buoyancy--The property of a liquid by which it puts an upward force on a body placed in it.
2. Displacement--The volume or weight of a fluid (as water) displaced by a floating body (as a ship) of equal weight.
3. Righting moment--A force that tends to restore a naval vessel to its upright position after it has been moved or tipped by wind or waves.

Supplemental Demonstration

Objective: To show force of water

Materials: One #10 can (like a large vegetable can from the school cafeteria).

- Procedure:
1. Punch four nail holes in the can at 1 inch intervals starting from the bottom.
 2. Fill the can with water and observe how water comes out of the holes.

Principle: The deeper the water the greater the pressure.



MAKING A PAPER BOAT

"ORIGAMI"

Supplies:

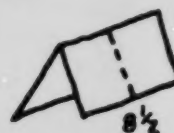
1. Enough 8 1/2" x 11" sheets of paper so each person in class will have one sheet.

Procedure:

1. Fold sheet in half lengthwise.



2. Fold sheet in half in opposite direction.



3. Open up second fold and make a 45° fold from upper left and upper right corners to center line of fold 2.



4. Fold bottom flaps up, one on each side. At this stage you have a hat.



5. Open up hat from bottom and flatten out at other corner; tuck in flaps.



6. Fold flaps up to top (one on each side).



7. Open from bottom

to get



8. Pull open at top

to get boat



RACE THE PAPER BOATS

Use toothpicks and paper to make sails on paper boats and have a sailboat race having students provide the wind.



NOTE: A race course can easily be set up by getting 2 ten foot sections of aluminum gutter, and sealing the ends. Place these on work benches and fill with water.

Student Activity #3

MODEL SHIP/BOAT BUILDING

Have students purchase a plastic model boat/ship of their choice, bring it to school and put it together during class.

Could be developed into a historical display of the evolution of ship/boat design.

SKETCHING

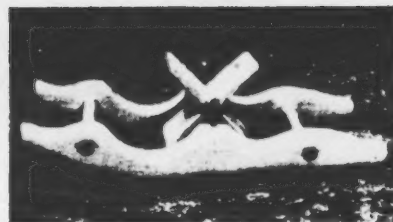
Have students sketch a design of a boat of the future. Use multiview and/or pictorial drawings.

Student Activity #5

CONSTRUCT A PADDLE BOAT

See attached instructions by William Lavin, School Shop, November, 1979,
page 33.

Paddleboat Motivates Students — from Start to Finish



These wooden paddleboats, powered by rubber bands, are inexpensive to make and teach basic woodworking skills.

By William J. Lavin

HERE'S a project that requires few materials and keeps student interest at a peak from beginning to end. It features the basic layout, cutting, and finishing of a simple wood project with the culmination of student competition against the clock. The paddleboat project is as natural as a junior high woodshop experience, because it insures a successful beginning work activity.

Introduce the project by showing students the completed basic shape along with a refined, shaped, and finely finished boat. The students should receive a working drawing of the side and paddle shape, suggestions for development of a nicely finished boat, and step-by-step directions for cutting, drilling, and assembly. They may cut, shape, drill, and smooth the two sides as they wish.

Design limitations are: all dowel holes must be located as indicated in Fig. 1; boat sides must be between 9" and 10" long and 3-1/2" apart; and the size of the paddle must be the same as in Fig. 1. There is no restriction on the size or type of rubber band used. Different types of rubber bands create different speeds and resistance in the finished boat.

Simple as it seems, this project offers

many standard woodworking operations. Besides the layout, there is face and edge drilling, ripping, planing, and shaping. Two special types of joints are included. The dowels connecting the two sides are secured to each side by small dowels inserted from the top edge. This prevents the boat from falling apart in the water. The second joint type is the cross-lap by which the two paddle pieces are locked together.

Construction.

1. Measure, mark and cut a piece of wood 3/4" thick, 2-1/2" wide and 24" long.
2. Lay out the shape of the boat side twice on the wood.
3. Mark the three locations for dowels on *only one* side piece.

4. Cut out and true the cut edges with a plane.

5. Place the two sides together (side marked with dowel hole locations should be up). Drill the first 3/8" hole through both pieces and insert a short piece of 3/8" dowel as an index for lining up both sets of holes. Drill the other 3/8" hole. It is imperative to drill both sets of holes in both sides at one time to ensure accurate alignment of the sides during assembly.

6. Drill the two 1/4" holes in the edge of each side (see Fig. 1).

7. Shape both halves to their final form, keeping in mind the design limitations.

8. Finish sand both halves using progressively finer grits.

9. Assemble both halves by drilling a 1/8" hole from the top edge so that a 1/8" dowel can be inserted into the side and

William J. Lavin is industrial arts teacher, West Genesee Junior High School, Camillus, New York.

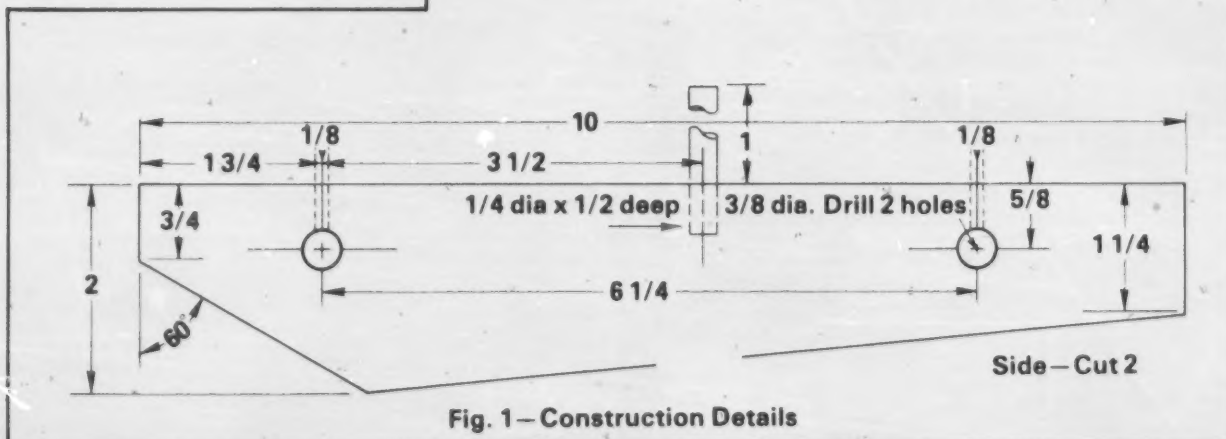


Fig. 1—Construction Details

end of the 3/8" dowel. To prevent misaligned holes, complete this operation one hole at a time. Drill and insert the first 1/8" dowel, and then proceed to the next.

10. Insert the 1/4" dowels for the



This 8' plastic-lined trough makes an excellent paddleboat "race course." Categories are fastest and slowest.

rubber band holder in each side.

11. Cut two pieces of wood 1/4" thick, 2-1/4" wide and 3-1/2" long for the paddle.

12. Lay out and cut a middle cross-lap joint (Fig. 1).

13. Sand smooth and join together with glue.

14. Varnish or paint and decorate to suit by adding adhesive decals, stripes, numbers, etc.

The race course. The climax of this project is a race against the stopwatch. A suitable water race course is a must. An inexpensive, easily constructed course is a plastic-lined trough made from 2x6 lumber, 8'-10' long. Four pieces of 1/2" plywood hold the sides apart. At each end, a piece of 2x4 acts as a separator and allows the liner to be attached.

For the liner, use a double thickness of construction-grade plastic sheathing. Tuck it straight down the sides and into the corners and secure around the top with thumbtacks at 6" intervals. Make sure the trough is on level ground by filling it with a few gallons of water and watching to see if one end is deeper than the other; if this is the case, block the low end.

Try to hold the race outside. If this is not possible and your shop has a floor drain, set up the trough near it. Be prepared for a leak by keeping rags and

buckets on hand to drain it quickly. Do not leave the water in overnight.

If your school has a plastics program, an interesting project is a plexiglass trough made from 8' rippings framed by 2x6 lumber. Water level in the pool should allow the paddle to rotate freely without hitting the bottom.

The race. Race day is as exciting to the junior high students as the Indianapolis 500 is to race fans. We compete in two categories, fastest and slowest boat. In either case, the boat must complete the full 8' course. Thick, heavy rubber bands unwind quickly and will not allow the boat to finish.

Boats entering the slowest race contest must always be moving forward. If their paddle stops or the boat hits the side and momentarily stops it is disqualified. Our times have ranged from 3.4 to 75 seconds over the same 8' course. The trick for boats entering the slowest competition is to use a very elastic, thin rubber band, turn the boat upside down and place it so that it is going backwards. The idea is to have as much drag and resistance as possible. There is usually more interest in the slowest category than the fastest, because there are more slow craft than the few super-fast boats. However, even for the losers there is always the Saturday night bathtub event at home with little brothers and sisters! □

BUILDING A SUBMARINE

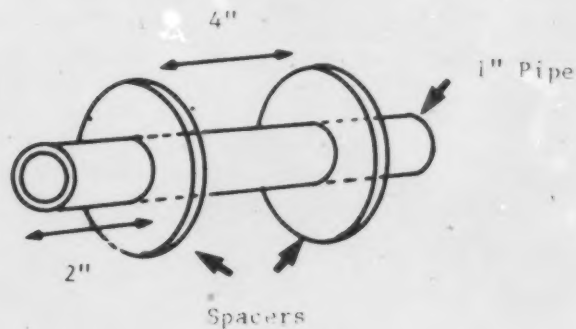
Ref: Info Sheet #7, TM #3.

Materials:

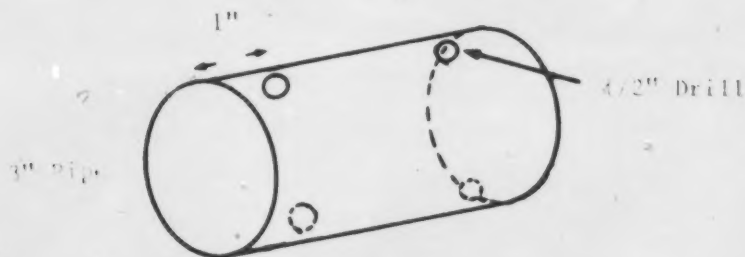
- 20 ft of rigid PVC pipe 3" diameter (outer hull).
- 20 ft of rigid PVC pipe 1" diameter (inner hull).
- 6 sq ft of clear plastic (ends of hull and spacers) each student needs 4 pieces - 3" square.
- 48 1/2" corks.
- Two large tubes PVC cement.

Construction Procedure:

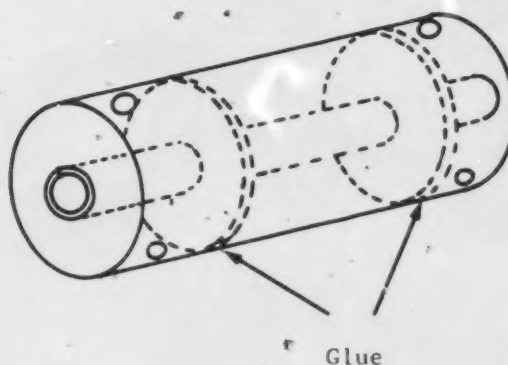
1. Cut an 8" long section of the 3" pipe and the 1" pipe.
2. Cut two circles 3" in diameter for end peices.
3. Cut two circles for spacers (diameter to just fit inside 3" pipe).
4. Drill holes in the center of the two spacers so they will fit over the 1" diameter pipe.



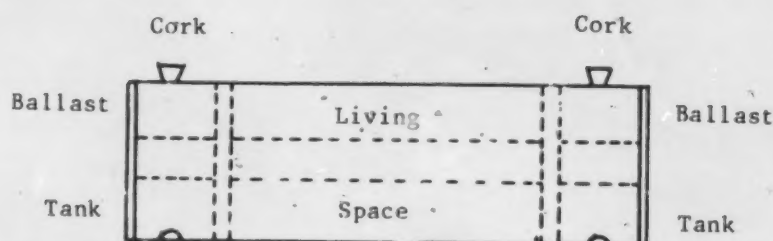
5. Glue spacers to 1" pipe 2" in from each end.
6. Drill four 1/2" hole in 3" pipe 1" from each end and on opposite sides of pipe.



7. After glue on spacers is dry, insert the assembly into the 3" pipe and glue spacers to 3" pipe.



8. Glue on end pieces.
9. Insert two corks in two top holes. You now have a submarine.



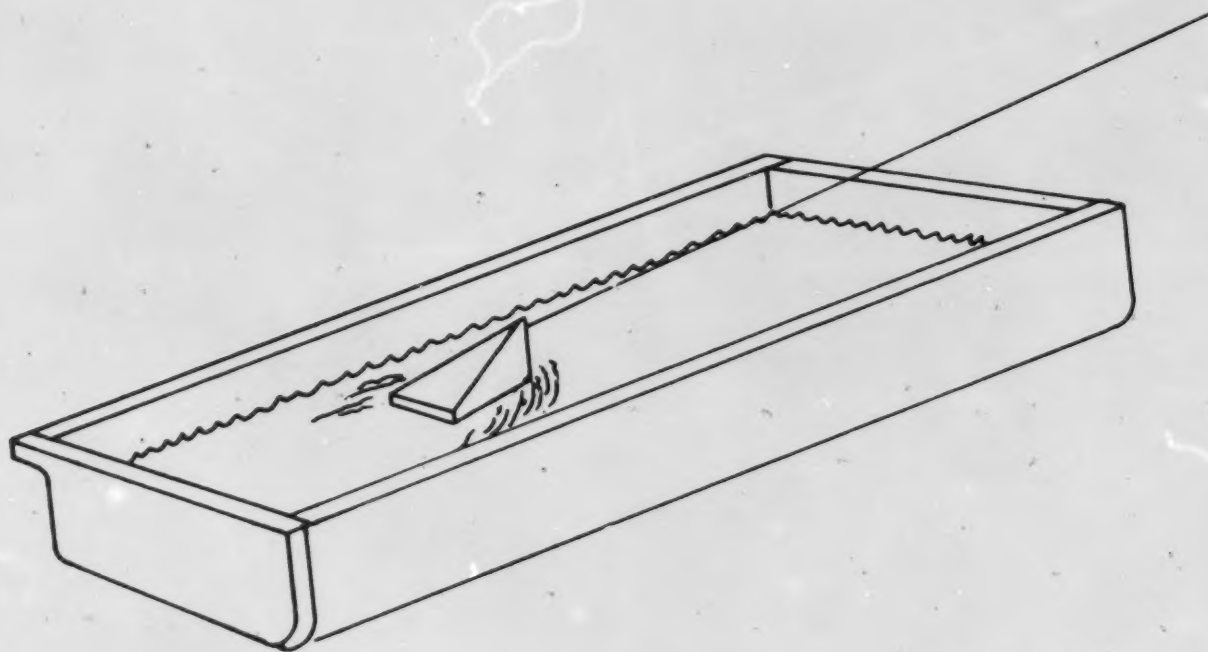
10. Place submarines in water and remove corks (main valves) and allow different amounts of water into ballast tanks so submarine floats at different levels and submerges.
11. Compare your submarine with your classmates as to how it works like a submarine.

NOTE: As an additional project, have students design a front and rear to this submarine main section.

DESIGNING A BOAT HULL

Using the concept of the "double wedge" in hull design, (1.) sketch a hull design for a small fishing boat or runabout, (2.) cut the pattern out of wood (note: keep sizes within limits of a 2 x 4), (3.) shape and smooth hulls, (4.) attach a string to bow of each model and pull boat through water troughs at a constant speed, (5.) observe waves made by each design (best design is one that makes the fewest waves).

NOTE: Pictures could be taken of waves and compared. This is how test runs are actually compared.



ADDITIONAL TEST: Paint hull designs and see if smoother hull reduces waves.

Student Activity #8

Have students design and build hydrofoils on their double wedge hulls and see if they can get them to work.

(NOTE) They may need to hollow out the 2 X 4 models to reduce weight.

Reference: Information Sheet #5.

DRAG BOAT

PROBLEM: Using the instructions below design and build a water vehicle for maximum speed.

MATERIAL FOR VEHICLE CONSTRUCTION

1. Students will be issued 1 Iasco D.C. motor to be assembled during class time.
2. The students will furnish (1) one "D" size non-rechargeable cell to power the motor.
3. Any material may be used in vehicle construction as long as design specifications are met.

DESIGN SPECIFICATIONS

1. Maximum length of vehicle 8"
2. Maximum width of vehicle 4"
3. Hull of vehicle must be handmade.
4. No modification of motor windings or magnets.
5. Motor chassis and shaft may be modified.
6. Special materials (gears, propellers, etc.)
Must be furnished by the contestants.

CONTEST RULES AND REGULATIONS

1. The contest will be held _____ 19__ at _____.
2. If designed specifications are violated, the vehicle will be disqualified.
3. The vehicles will be clocked from start to finish a distance of 8 feet. The bow will be placed behind the starting line. The contestant will start the motor. When the vehicle is released, the timekeeper will start the clock. When the bow reaches the finish line, time will stop.
4. If water is too choppy the judge may delay the race until the water quiets.
5. A prize will be given for the most attractive vehicle.
6. A final sketch of the vehicle must be submitted before the contest.

- DRAG BOAT -

—A PROBLEM IN WATER TRANSPORTATION—
CONSTRUCT AN OPEN BOAT FOR MAXIMUM SPEED
USING THE FOLLOWING DESIGN AND MATERIAL
SPECIFICATIONS:

DESIGN - Submit 3-View Drawing of Boat
Design Before Beginning
Construction

- Submit Bill of Materials
- Drawing Should Be Half Scale
- Use This Sheet As A Format.
- Observe Maximum Dimensions
Indicated on This Sheet.

- CARGO MATERIAL
- All Dimensions Must Be Metric
 - 100 Grams Of Lead Ballast (Shot)
 - Balsa
 - Plastic Film
 - Adhesive-Glue
 - Sealer
 - Eye Screw To Be Attached
To Front Of Boat (Bow)

NOTE: THIS IS A COMPETITIVE ACTIVITY

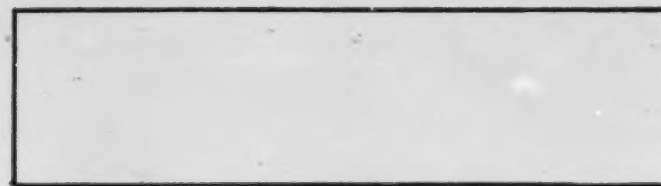
BILL OF MATERIALS

PT #	NAME	MAT.	QUANT.

MAXIMUM WIDTH
75 MM



MAXIMUM
HEIGHT
50 MM



MAXIMUM LENGTH 200 MM

621

DRAG BOAT

NAME:

SCALE: 1:2

WT 1.37

Student Activity #10

Class Project

Build a surface effect boat.

Reference: Plans available at sources listed in reference section of introductory unit to all of transportation.

Student Activity #11

CLASS PROJECT

BUILD A ROPE MAKING MACHINE AND MAKE ROPE FROM TWINE

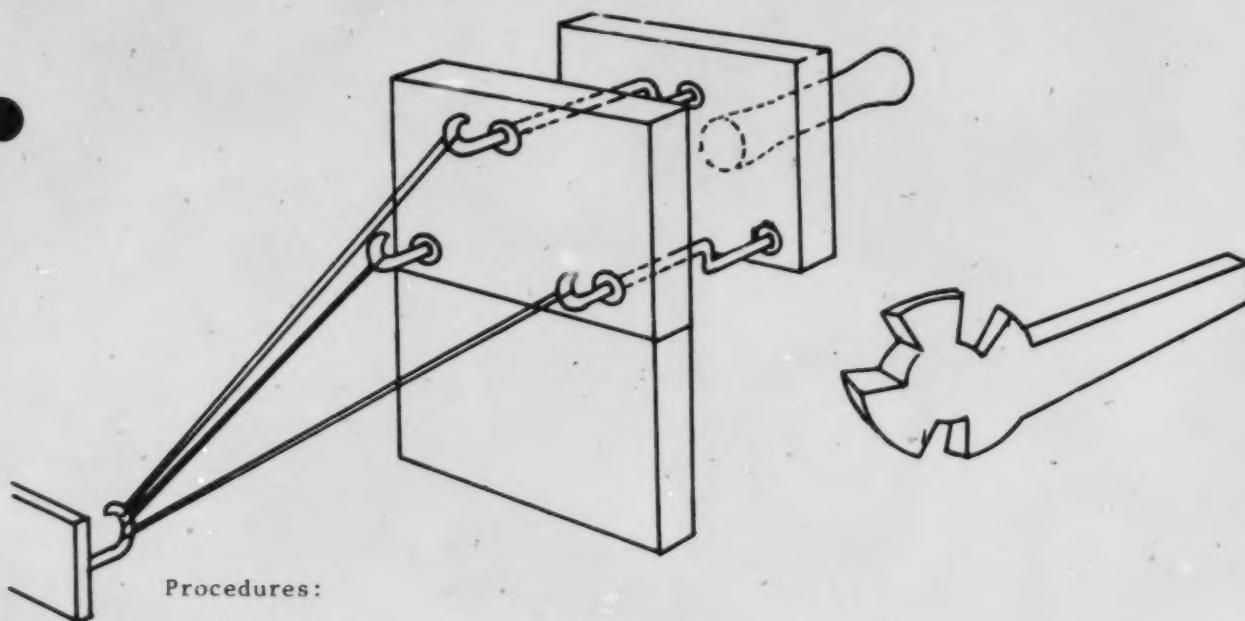
Research:

Go to library and look up information on rope and what different materials are used in its manufacture.

Construction:

Materials:

1. 2 pieces of 1/2" plywood 4" square (A&C), 1 piece 4" x 8" (A).
2. 3 wire coat hangers (heavy gauge wire).
3. One package of small flat washers (center hole 1/16 to 1/8" dia.).
4. One piece of 1" dia. dowel 6 inches long (handle).



Procedures:

1. Lay out an equilateral triangle on two of the pieces of plywood and drill 1/8" holes at the vertex of each angle. (A&B)
2. Cut coat hanger wires into 3 six inch lengths. (do each step with each wire)
 - a. bend a V-shape on one end of wire.
 - b. insert straight portion through drilled holes in one block.
 - c. apply washer on wire.
 - d. bend wire at 90° angle.
 - e. at a point 1-1/2" from first 90° bend, make another 90° bend to form crank.

Procedures (continued)

3. f. apply another washer.
g. insert wire through second block and add a washer.
h. bend wire at 90° to hold in place.
4. Drill 1/8" hole in center of third piece of plywood and insert a piece of wire with a big hook on one end to hold other ends of string.
(Part C)
5. Drill hole in center hole of part B and attach handle with wood screw.

Rope Making Procedures:

Supplies: One ball of hay bale twine.

1. Fasten block (A) securely in a vise or some other device.
2. Fasten block (C) to a belt and fasten belt around a student.
3. Loop twine over the three hooks on block A and fasten to the hook on block C.
4. Turn handle on block B to rotate hooks on C to twist twine into rope.
5. While handle is being turned, insert paddle (D) in between strings and push twists toward block (C) to make a tight rope.
6. Keep turning handle until twine is twisted completely between blocks C and A.
7. Cut rope off blocks and tape ends.

NOTE: Recommend starting rope lengths to 10 feet maximum.

ADDITIONAL STUDENT ACTIVITIES

1. Visit a local marine dealership and view boats and different propulsion systems.
2. Various outboard companies have promotional films (i.e., Evinrude/Johnson, Mercury, etc.).
3. Boat companies may also have films.
4. Boating safety films are excellent for avocational information also. Usually available from insurance companies, such as Aetna and others.

TEST 1

Match terms with definitions:

- | | |
|---|--------------------|
| _____ 1. Person who steers a boat or a ship. | A. Ship |
| _____ 2. The property of a liquid by which it puts an upward force on a body placed in it. | B. Buoyancy |
| _____ 3. A large seagoing vessel. | C. Aboard |
| _____ 4. A blunt-ended craft used to haul supplies. | D. Displacement |
| _____ 5. The volume or weight of a fluid (as water) displaced (pushed aside) by a floating body (as a ship) of equal weight. | E. Anchor |
| _____ 6. In or on a ship. | F. Righting moment |
| _____ 7. A force that tends to restore a naval vessel to its upright position after it has been moved or tipped by wind or waves. | G. Helmsman |
| _____ 8. Enclosure on the boat or ship that has the main steering controls. | H. Boat |
| _____ 9. A device that rests on the bottom of a river, lake, or ocean that is fastened to a boat or ship to keep it from moving. | I. Pilothouse |
| _____ 10. A small craft capable of being carried aboard a ship. | J. Barge |

TEST 2

HISTORICAL DEVELOPMENT OF WATERCRAFT

Place the statements below in numerical order as they happened in the development of water transportation.

- _____ A. The first submarine was developed.
- _____ B. Iron ships were made (MONITOR).
- _____ C. Three masted ships were developed.
- _____ D. One masted ships were developed.
- _____ E. Dugout canoes and coated baskets were used.
- _____ F. Large oil tankers were built.
- _____ G. Robert Fulton made one of the first steam boats.
- _____ H. Many new military ships were designed.
- _____ I. Nuclear power used to move ships.
- _____ J. TVA was developed.

TEST 3

Describe four (4) technical jobs/occupations connected with water transportation. List working conditions and some things that a person does in each job.

1.

2.

3.

4.

ANSWERS TO TEST 1

Match terms with definitions:

1. G
2. B
3. A
4. J
5. D
6. C
7. F
8. I
9. E
10. H

WT 1.45

ANSWERS TO TEST 2

HISTORICAL DEVELOPMENT OF WATERCRAFT

- A. 4
- B. 6
- C. 3
- D. 2
- E. 1
- F. 8
- G. 5
- H. 7
- I. 10
- J. 9

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

WATER

Title of Unit:

INLAND WATERWAYS

DESCRIPTION OF UNIT

This unit will cover inland waterways to include rivers, canals, and lakes as they are used for transportation and recreation. Industrial arts type activities are incorporated as they relate to water transportation and its supporting areas. The materials in this unit are designed for 30 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to identify the general locations of the inland waterways in the United States to include rivers, canals, and lakes. The student will also be able to explain/describe the lock system and styles/types of inland water craft by actually building one or more models of each, and completing a unit test with a score of 80% or better.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. Locate a map of the United States, the locations of the major river, lake, and canal waterway systems.
2. Demonstrate the ability to construct a model river tugboat and barge, and/or Great Lakes ore boat.
3. Assist in a class/group project of designing, constructing, and testing a lock system.
4. Discuss orally the relative importance in cost and amount of goods moved by water as compared to other means of transportation.

WT 2.2

- 5.° List a minimum of 4 technically oriented jobs/careers related to inland water transportation.
6. Discuss orally the procedure for passing through a lock safely.

OUTLINE OF CONTENT

I. Development of Inland Waterways (Information Sheets A's & B)

A. Brief History

1. America has many large rivers--over 25,000 miles of inland waterways, canoes probably first craft.
2. Rivers were the first highways in America so many cities are on river.
3. Later canals were dug to widen and deepen river and lakes and then to interconnect them.
4. Flatboat and keelboat era.
5. Steamboat era.
6. Modern towboat and barges.

B. Main River Systems (TM #1)--Most traffic in barges.

1. Ohio
2. Mississippi
3. Tennessee
4. Missouri
5. Snake
6. Yukon

C. St. Lawrence Seaway System (TM #1)--Most traffic is special "boats" to haul grain, iron, ore, coal, and limestone.

1. St. Lawrence River
2. Lake Erie
3. Lake Huron
4. Lake Michigan
5. Lake Ontario
6. Lake Superior

D. Intercoastal Waterway System (TM #1)

1. Begins in New York and runs along the entire East coast, around Florida and all along the Gulf Coast through Texas to Mexico.
2. Natural and constructed routes make this a unique waterway over 2,300 miles long.

II. Inland Waterways--Today

A. Locations

1. Rivers and Canals (TM #1)
2. Great Lakes & St. Lawrence Seaway (TM #1)
3. Intercoastal Waterway (TM #1)
East Coast & Gulf Coast

B. Making Streams and Lakes Navigable

1. Dredging and channeling (Information Sheet #C)
2. Lock system
 - a. design (TM #2)
 - b. passage through a lock

C. Use of Inland Waterways

1. Commercial (Information Sheet #E)
 - a. hydroelectrical power
 - b. shipping (TM #3 & #4)
2. Recreational
 - a. fishing, boating
 - b. swimming, water skiing, etc.

D. Useful Marine Knots (Student Activity #4) (Information Sheet #F)

1. square
2. bowline
3. becket bends

4. round turn
 5. half hitches
 6. clove hitch
- E. Construction of Inland Watercraft/Waterways
1. Commercial (Information Sheet #C)
 - a. tow boats
 - b. barges
 - c. ore boats
 2. Recreational
 - a. fishing and pleasure boats
 - b. house boats and pontoons
- F. Development of Waterways in Tennessee
1. Ohio River Division (TM #5)
 2. U.S. Army Corps of Engineers (TM #6)
- G. Power Sources for Inland Watercraft
1. Commercial (See Prime Movers)
 - a. diesel
 - b. steam turbine
 - c. gas turbine
 - d. other
 2. Recreational
 - a. diesel
 - b. inboard
 - c. outboard
 - d. other

WT 2.6

H. Jobs Related to Inland Water Transportation Systems
(Refer to Dictionary of Occupational Titles.)

1. Construction
2. Manufacturing
3. Power sources
4. Operator of equipment

TEACHER ACTIVITIES

1. Provide students with student modules.
2. Make transparencies.
3. Discuss unit and specific performance objectives.
4. Discuss topics using outline of content as a guide and use TM's and information sheets as needed.
5. Discuss student activity sheets giving demonstrations on tool use as needed.
6. Relate types of inland water vessels to types of prime movers (power sources) normally used with each.
7. Plan a field trip to a nearby TVA facility, (check TM 5 and TM 6 for location) or invite guest speakers from TVA to class.
8. Lead class discussion on technical jobs/careers in inland waterway transportation.
9. Show films on inland waterways, TVA recreation, etc.
10. Review material presented and discussed.
11. Give unit test.

STUDENT ACTIVITIES

1. Read objective sheets.
2. Study information sheets.
3. Complete activity sheets assigned.
4. Participate in class discussions, activities, field trips.
5. Take tests.

REFERENCES/RESOURCES

References:

Geil, John T. and B. Stephen Johnson, Energy and Transportation: Industry and Careers, MET Series, Prentice Hall, N.J. 1976.

Resources:

Nashville District
U.S. Army Corps of Engineers
P.O. Box 1020
Nashville, TN 37202

U.S. Department of Transportation
Washington, D.C.

U.S. Navy Films for the Public
Office of Information
Dept. of Navy
Washington, D.C. 20350

INLAND WATERWAY TRANSPORTATION PUBLICATIONS FOR CLASSROOM USE

1. Locking Through; Copies of this publication may be obtained by writing:

District Engineer
U.S. Army Engineer District Nashville
P.O. Box 1070
Nashville, TN 37202

2. Recreation on T.V.A. Lakes; Copies of this publication may be obtained by writing:

Division of Information and Tourist Promotion
Department of Conservation
2611 West End Avenue
Nashville, TN 37203

DEVELOPMENT OF INLAND WATERWAYS

The first types of inland waterway craft were rafts or other objects that floated. Indians developed canoes and they were the main source of transportation when settlers moved across America.

To haul larger amounts of cargo, flatboats and keelboats were developed. Flatboats simply floated downstream only and had poor steering. The flatboats were usually taken apart at the end of the trip and the logs sold. Keelboats were capable of moving sizable amounts of cargo upstream. They were poled, pulled, pushed, and sailed but this was a very slow and difficult task.

After the war of 1812, steamboats began appearing on the waterways and soon put the keelboats out of business. The flatboats continued to prosper until about the 1860's. From the 1840's to the 1880's steamboats carried most of the cargo. Steam propelled towboats were also developed and began moving barges up and down the river systems towing keelboats. Steamboats began to decline in the 1880's and were nearly gone by 1900. Only a few continued in operation until the Depression of the 1930's.

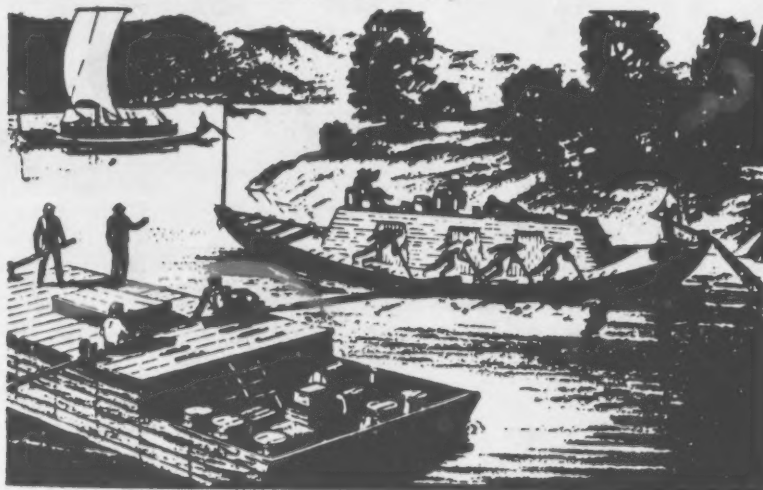
Barge towing continued to grow after the disappearance of steamboats and the main power source of the towboats was steam. By the middle of the 1940's about half the towboats were diesel. By 1955, nearly all towboats were diesel powered. The power and efficiency of towboats has steadily increased to the present where a single towboat can tow many barges at once.

Not all parts of the inland waterways that we have today were originally deep enough to allow traffic so they had to be dredged out. This process is called canalization.

The process of canalization was completed in 1929 after nearly 100 years of dredging and lock building. Dredging and channel clearing is a continuous task and continues at the present. This is carried out by the Corps of Engineers primarily through contractors.

Development of Inland Waterways

An early scene on the natural river, showing a flatboat and two keelboats



A Merger of Two Eras

The "historical background" in this booklet ends with the beginning of the steamboat era.

Before the steamboat, flatboats and keelboats were the major means of transportation along the Ohio and its tributaries. The flatboats floated with the current with control limited to steering. The keelboats were the only sizable craft capable of moving cargo upstream. They were poled, pulled, pushed, warped, cordelled, bushwhacked, and even sailed. But the operation was arduous, time consuming, and expensive. As a conse-

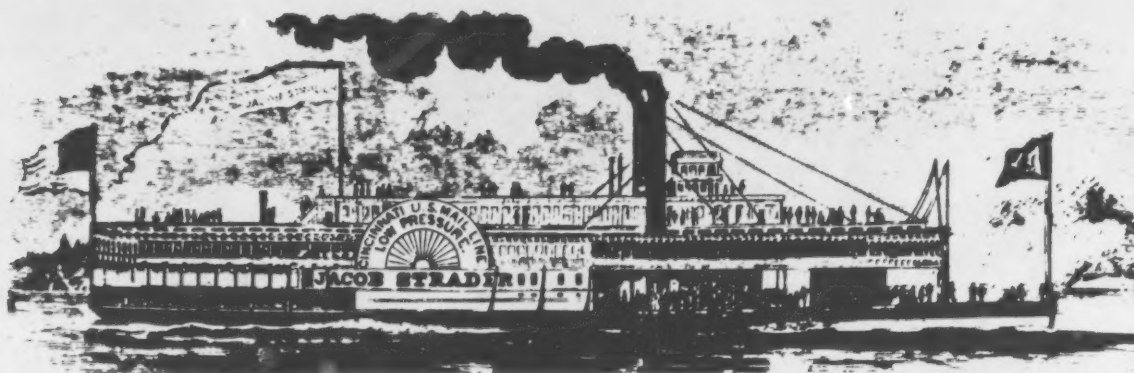
quence, as the use of steamboats, with their greater capacity, economy, and speed, began to develop soon following the War of 1812, the keelboats lost their former special advantage and were soon out of business.

The flatboats, however, continued to prosper. As the Ohio country grew, the need for flatboats was greater than ever. By the mid-1840s 1,200 steamboats were plying the western waters, but there were 4,000 flatboats as well, accounting for close to a third of the total tonnage.

In 1847, the peak year, more than 2,200 flatboats from the Ohio valley landed in the New Orleans area. Thereafter this trade fell off rapidly, though many flatboats continued in use on local and feeder routes.



A seagoing sailing vessel was built on the Monongahela as early 1793. Shown here are oceangoing ships at Marietta. About twenty-five such vessels were built there between 1800 and 1808. From a painting in the Campus Martius Museum.



The Jacob Strader, 905 tons, was built in Cincinnati in 1853 for the Cincinnati and Louisville Mail Line. With a length of 347 feet she was the largest boat on the river. The hull, with a width of 27-1/2 feet, supported a main deck 69 feet wide

The steamboat construction boom gave an enormous boost to Ohio valley industrial development, and the speedy, economical transportation the steamboats furnished accelerated commercial growth and ended the frontier isolation of the region.

Imposing three-decked steamboats carrying several hundred passengers came to be a common sight.

The 50s were the bright years of steamboating in terms of amount and quality. But the decade was marked by depression and misfortune and the beginning of the trend toward decline.

Design of the Western Steamboat

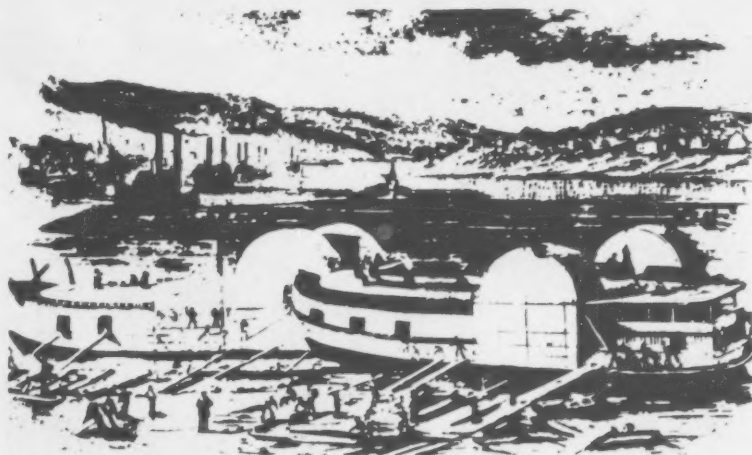
For operation on the western rivers the steamboat builders evolved a flat-bottomed vessel of great buoyancy, the hull long and slender, with the ends modelled for an easy entry and run.

The features of design of the typical main-line steam packet are described by Alan L. Bates in the September 1966 issue of the *S & D Reflector*. The guiding principle: "The boat that could run a week earlier and continue a week longer was a winner at the cash box." These boats made good speed, and saved time, too, because of fewer groundings.

The hull was six to nine times as long as it was wide and forty to fifty times as long as it was deep. To stiffen the flexible and lightly built wooden craft the hogchain system of bracing was developed. Hogchains were wrought iron rods firmly fitted at the forward and after ends of the hull and led up over tall timber braces. The purpose and effect was to keep the ends of the boat from sagging.

The main deck was wide open, with all space not occupied by boilers and machinery used for stowing freight. The passenger cabin, above the main deck, consisted of a center hall or grand saloon, running nearly the full length of the boat, flanked by compact

Steamboats in the Civil War period. Gunboats being fitted out at Cincinnati for Union service on the Mississippi. From Harper's Weekly, 13 July 1861



Overall, the river steamboat trade reached its zenith between 1840 and 1860. On the one hand, the beginning and the growth of railroad building and use in the Ohio River drainage area, and on the other the mounting use of mass transportation on the rivers by means of barges and towboats, spelled the decline of the steamboat. The needs once served by the steamboat packets came to an end in the 20th century, with only a few continuing in operation until the Depression of the 1930s.

Change in Trade Direction

Before 1845 the Ohio basin relied basically on the Ohio-Mississippi waterway as a route for market contact. New Orleans served as the focal center for trade not only with the South but with the Atlantic seaboard and abroad.

For thirty years before the Civil War, however, the river route was losing its earlier dominance. First the canals in the 1830s and 40s, then the railroads in the 50s, brought about a redirection of trade from a mainly southern orientation to an increasingly east-west routing.

The river commerce lost much of its interregional character and became more largely regional. The development of roads, canals, and railroads, in combination with burgeoning commerce in the Erie Canal-Great Lakes region to the north brought about an ever growing and an ever changing transportation structure.

The decline of the rivers was relative, however, rather than absolute. The rivers continued important in freight movement—though of diminishing use in passenger travel—right up to the beginning of the war.

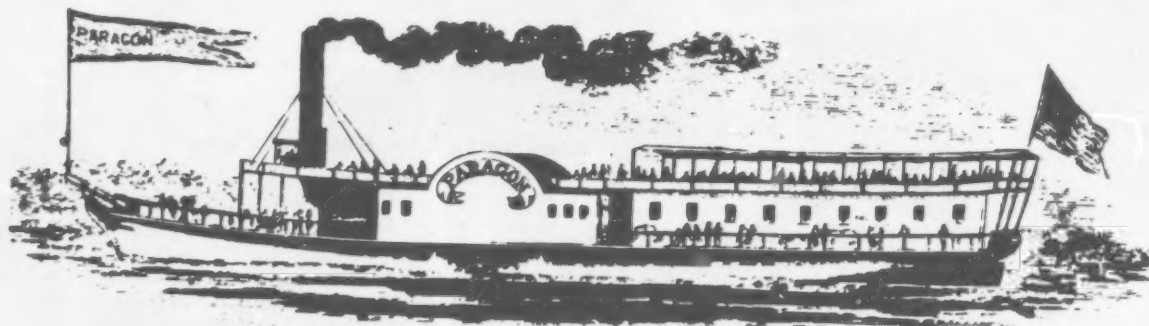
The Civil War disrupted normal traffic on the inland rivers, and the Mississippi below Cairo was closed to commercial use. Ironclad gunboats were built at St. Louis and Cincinnati, and the majority of steamboats were used as transports for troops and supplies.

Rebuilding of traffic on the rivers following the war was slow, and many readjustments took place. But there was a resurgence of steamboat traffic. The general trend was upward until about 1880.

Measure of Steamboat Use

As summed up by Leland Johnson in his history of the Huntington District of the Corps of Engineers:

Nearly 6,000 steamboats were built along the inland rivers between 1820 and 1880, and, from first to last, about three-fourths were built in the Ohio valley.



The Paragon (355 tons), built at Cincinnati in 1819, was, in her period, one of the largest and finest boats on the inland rivers. Hunter states that "within a year of her maiden voyage she had completed the trip from New Orleans to Louisville with full cargo in seventeen days and seven hours"

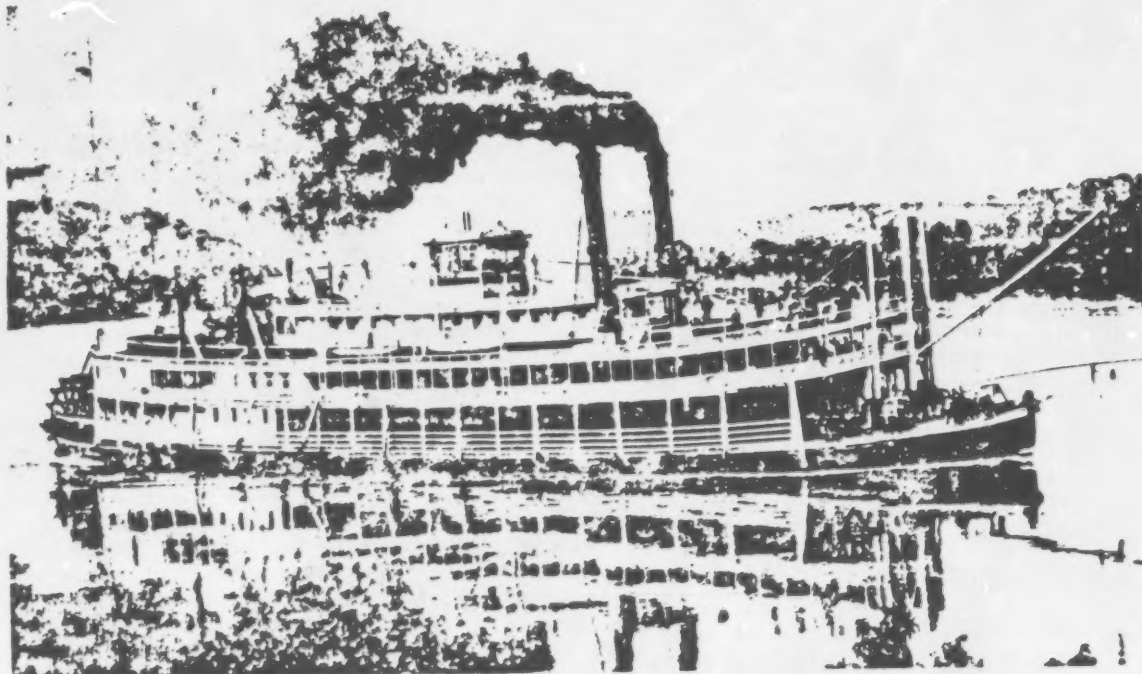


Photo portrait of the Queen City taken about 1900, while piloted by Captain Anthony Meldahl. The Queen City was built in Cincinnati in 1897 for the Pittsburgh and Cincinnati Packet Line. The vessel was 235 feet long and 44 feet wide (51 feet over the guards). The main cabin, 200 feet long, was finished in burnished mahogany. The photograph brings out the intricate hogchain system. The boat sank twice, in 1909 and 1914, and spent its last days, to 1933, as a wharfboat at Pittsburgh. The engines of the Queen City were second hand. They were constructed in 1880 for the Florida, a sidewheeler built in Sewickley and Pittsburgh for the Savannah-Jacksonville trade. According to the S & D Reflector "the old Florida engines were picked up in Florida for \$100 plus rr. charges to Cincinnati"

and simply fitted staterooms on each side. A broad sheltered promenade surrounded the cabin and staterooms.

The impression of luxury was limited to the center hall, which served as dining hall as well as social center.

Twin smokestacks were used, giving a balanced appearance to the boat while leaving the grand saloon unimpeded. The sheer curve—the rise in the main deck at bow and stern, designed to prevent waves from washing aboard—added grace to the vessels and was repeated all the way to the highest roof.

Variations among Steamboats

Actually, the steamboats presented many variations in size and appearance, some of them leaning decidedly toward simplicity and plainness—even ugliness.

Of necessity, smaller steamboats were developed for use on tributary streams such as the Muskingum, the Kanawha, the Little Kanawha, and the Guyandotte. A small side-wheeler type known as the batwing came to

be particularly identified with the Big Sandy, including the Levisa Fork.

Wood the Favored Material

The merit of iron hulls for steamboats began to be recognized about 1825, but on the western rivers, wood, the familiar and abundant material, continued to be used for virtually all commercial vessels. The low first cost of wooden hulls appeared to be the compelling factor, even though the iron hulled vessel might be expected to outlast five or more wooden ones. What with sinkings from snags, collisions, groundings, fire, and explosions, the average life of the western river steamboat was reckoned at only five or six years.

It was not until about 1880 that a Pittsburgh firm began to specialize in building steel hulled vessels. And most of those boats were built for export. As found by Louis Hunter, as late as 1906 only about 5 percent by number and 10 percent by tonnage of the western river boats had hulls of iron or steel.



The Mississippi River at New Orleans as shown in Picturesque America (1872). The commingling of various types of vessels, including oceangoing sailing ships, is notable. New Orleans was the focal point of the economy of the Ohio-Mississippi basin until the railroads tied the interior to the Atlantic coast

Steamboat Era

The first steamboat to navigate the Ohio River was the *New Orleans*, built at Pittsburgh in 1811 by a Fulton enterprise, only four years after the *Clermont* was placed in operation on the Hudson. The *New Orleans* descended the Ohio never to return, but many interests devoted themselves in following years to the development and building of steamboats better suited to use on the inland rivers.

The success of the western river steamboats and their impact on the Ohio valley was largely responsible for the enactment of the first Waterways Improvement Act, in 1824. Before the Civil War the principal function of the Army Engineers in the Ohio valley was the improvement of waterway navigation for the benefit of steamboat commerce.

Henry Shreve is credited by historian Archer B. Hulbert with solving the problem of the western river steamboat by designing the *Washington*, "to sail on the water instead of in it, doing away altogether with a hold and supplying an upper deck in its place." The

Washington was built at Wheeling in 1816 and set a pattern for the river steamboats which followed.

With the steamboat, the Ohio became in effect the western extension of the National Road when it reached Wheeling in 1818.

Definition of the Steamboat Era

The steamboat era is not easy to define. Author Frank Donovan wrote that it lasted a century, "fifty years on the way up and a like period on the way down." Paradoxically, he continued, the most glamorous and dramatic part of the era was the period of its decline, a period of floating palaces with gourmet menus and paintings and mirrors hung above "acres" of specially woven Brussels carpet in luxurious main cabins—"the era immortalized in Edna Ferber's *Show Boat* and countless other almost legendary tales of the river boats."

Two pairs of coalboat bottoms, loaded with lath, shingles, etc., floating down the Allegheny. The photograph was probably taken in the late 1890s, but the scene suggests the appearance of coalboats of an earlier period, floating downstream without benefit of powered assistance. The bottoms were unloaded at Pittsburgh and towed to "siding yards" to be made into large coal barges.



Development of Mass Movement

Mass movement as used here refers to large-scale shipment of commodities. The method has its application mainly to low-priced bulk commodities, notably coal, and on the inland waterways it implies the use of unpowered barges.

The mass movement principle in the modern era is aptly expressed in the title of *Big Load Afloat*, issued by American Waterways Operators, Inc., and the equipment used and the procedures employed are effectively described in that publication.

The first bulk-loaded barges simply floated with the current and were used in downriver movement only. Later, steamboats were used to guide, control, and propel the barges. Specially designed steam towboats were then used over a long period, and diesel towboats are now the source of power.

Early Bulk Shipments

Coal was shipped down the Ohio as early as 1793 by the Army Quartermaster Department to supply garrisons at forts on the frontier. Commercial shipments were begun within a quarter of a century, to supply river steamers, riverside industries, and steamships and sugar refineries at New Orleans. Coal from the Monongahela was first floated down the Ohio in 1814, and shipments from Pomeroy, Ohio, were begun in 1819.

The early shipments were loaded in roughly framed and planked coalboats, resembling flatboats, which were sold along with the coal at destination. The first coalboats were about 80 feet long by 18 feet wide and drew 40 inches. Later these boats were built to a length of 175 feet and a width of 26 feet, drawing 8 feet when

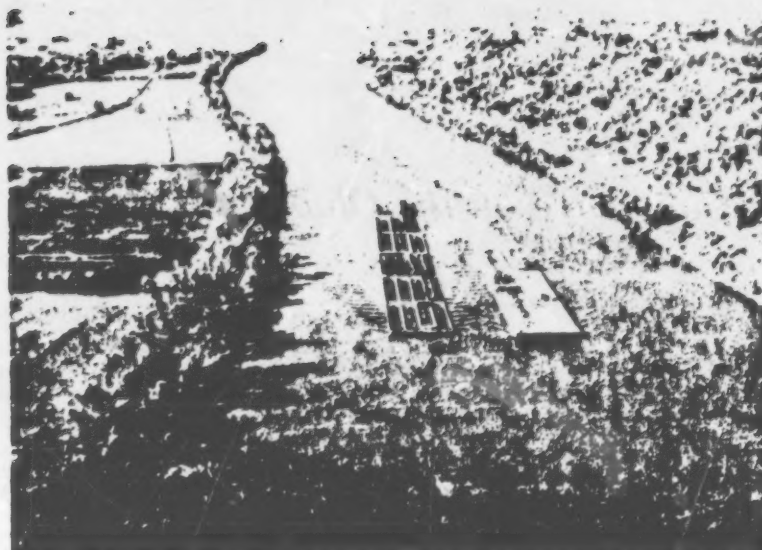
loaded with 24,000 bushels of coal. The boats were usually lashed together in pairs and floated downriver at high water stages, steered with long oars in the fashion of flatboats. Coalboating could be a dangerous business—seventy coalboats and seventeen crewmen were lost in an Ohio River storm of 1854, and coalboat losses averaged 10 percent annually. Profits, however, were high.

Trend toward Barge Towing

Milnor Roberts noted in 1866 that the one-way coalboats were gradually being replaced by steamboats towing fleets of coal barges downriver and returning the empty barges upriver for reuse.

The towing of keelboats behind and at the side of steamboats was begun almost from the start of the use of steamboats on the Ohio. The steamboat *Condor*, pushing keelboats lashed alongside from Pomeroy to Cincinnati in 1836, may have been the first to tow coal on the Ohio. Placing barges ahead of steamboats and pushing them became a common procedure during the 1840s. The first Ohio River towboat taking coal to New Orleans delivered 2,280 tons in four barges in 1854. But within a few years the size of the barges, the power of the steam towboats, and the number of barges in a tow had been greatly increased.

Milnor Roberts reported that, including shipments from Pittsburgh, Wheeling, the Kanawha, Pomeroy, the Big Sandy, Hanging Rock, and Ashland, 40 million bushels of coal (about 1.5 million tons) was shipped down the Ohio River in 1866 and that at least ninety steam towboats were engaged in the coal towing business. He saw the development of the barge towing



Two upbound modern tows, passing Antiquity, Ohio, on the Gallipolis pool of the Ohio River. In the distance, on the West Virginia side of the river, are a steam-electric generating station and a nearby ferroalloys plant

Regardless of the type of drive, whether sternwheel, propeller or electric, the advantages of the Diesel are equally applicable.

The extent to which the diesel engine was coming into use in Ohio River towing is suggested in the Corps handbook on *The Ohio River: 1934*. Ten river points were listed where diesel fuel oil could be obtained: Pittsburgh, Steubenville, Wheeling, Huntington, Cincinnati, Louisville, Evansville, Paducah, Metropolis, and Cairo. Sixteen points were named where coal could be obtained.

Steam Dwindles, Efficiency Increases

When the canalization of the Ohio River was accomplished in 1929, many steamboats were still in use and the towboats were typically steam-powered. The use of steamboats quickly dwindled during the Depression, however, and by the mid-40s fully half the towboats were diesel. By the mid-50s the changeover to diesels was almost complete. The power and efficiency of the towboats, meanwhile, steadily increased, and this improvement has continued.

The towboat A. N. Prentice with a fifteen-barge coal tow on the Ohio River near Louisville



Data on the sizes of present-day towboats and barges and the capacities of tows are included in Part II of this booklet: *Ohio Navigation as It Is Today*.

An accompanying table presenting figures on the

tonnages and ton-miles of waterborne commerce on the Ohio River provides a measure of the remarkable growth of the mass movement on the Ohio since the period of World War I.

Waterborne Commerce on the Ohio River 1915-1977

(At five-year intervals, 1915-75)

Year	T O N N A G E (In thousands)						Ton-Miles (In millions)
	Coal and Coke	Petroleum Products	Aggregates	Chemicals	Iron and Steel	All Other	
1915.....	4,546	4	2,024		26	747	1,095
1920.....	6,651	46	1,239		367	1,078	1,184
1925.....	6,925	271	7,406		580	555	826
1930.....	9,769	482	9,526		1,481	1,079	1,474
1935.....	12,812	1,564	4,144		1,136	1,321	2,254
1940.....	16,608	3,997	5,545		2,114	1,285	3,853
1945.....	18,458	8,370	4,261		1,139	1,640	6,065
1950.....	23,860	11,733	8,12		2,310	2,442	8,800
1955.....	37,963	14,517	9,958	1,647	4,369	3,007	14,901
1960.....	39,904	16,337	10,137	3,355	3,685	6,060	17,704
1965.....	46,606	20,508	14,209	5,961	3,439	12,451	23,275
1970.....	59,001	25,312	17,240	10,583	4,382	13,067	30,254
1975.....	73,301	19,620	16,491	9,069	3,896	17,678	32,320
1977.....	81,593	19,255	17,963	9,311	4,266	19,009	37,476

Chemicals are included in "All Other" in the years 1915 to 1950.

Cost of Inland Waterways

Whether water transportation is truly low cost depends on the sum of all costs involved. This includes the cost of publicly as well as privately provided equipment, facilities, and operations. The amount of improvements necessary before water transportation is feasible, of course, varies substantially from one segment of the total system to another. In relation to volume, the public costs associated with Great Lakes transportation have been minimal. The cost of improvements for barge navigation on the portion of the Mississippi River below St. Louis has likewise been relatively low. Conversely, other sections of the domestic waterway system have required very extensive and expensive lock systems. The original investment required was large, and substantial maintenance and operating expenses continue to be incurred. Whether or not water transportation so expensively provided is truly low cost is open to question. Particularly suspect, solely on economic grounds, and in view of alternative transportation available, are such current projects as the Arkansas-Verdigris River, the cross-Florida canal, and the proposed Lake Erie-Ohio River waterway.

The last six Presidents have all proposed that charges be assessed the users of the domestic waterways. The theory is that the cost of economically justified improvements should be at least in part recoverable. Thus far, however, no user charges have been imposed. A major difficulty stems from the fact that waterway improvements serve multiple objectives: e.g., flood control, hydroelectric power, recreational facilities, as well as navigation capabilities. Hence, a basic problem has to do with determination and equitable allocation of costs among the diverse beneficiaries of such multiple-purpose projects. In addition, there is the very serious problem of economic disturbance to existing carriers, shippers, and localities which would occur as a result of imposing user charges where none have previously existed.

In view of an apparent increased awareness of the need for rational allocation of the economic resources of the country and the availability of improved costing techniques, it is possible that closer scrutiny will be given to the economic justification of future proposed waterway improvement projects and also to the possible recoupment of a portion of past investment and/or current maintenance and operating costs.

THE WATERWAY NET—DEVELOPMENT AND FUTURE OUTLOOK

Coastwise and Intercoastal Shipping

"Coastwise transportation" refers to movement between ports along the seacoasts, i.e., between Atlantic ports and/or between Gulf ports, and between Pacific ports. "Intercoastal transportation" encompasses movements between ports on the coasts through the Panama Canal.

These categories of domestic deep-sea shipping represent the oldest form of transport in the United States, the origin of which dates back to colonial times, nearly a century before the advent of the railroads. With the population largely concentrated along the Atlantic seaboard, contacts among the colonists and later between the States, as well as with the rest of the world, were dependent almost entirely upon seaborne transportation. Coastwise and intercoastal shipping were among the first commercial enterprises developed by American colonists.

An important point with respect to this transportation is that almost from the inception of this Nation, coastwise and intercoastal trade has been restricted to vessels built, owned, and operated by citizens of the United States. This requirement stems from the principle of "cabotage," currently embodied in the "Jones Act" or Merchant Marine Act of 1920, an early purpose of which was to assure at least the nucleus of a national-flag fleet. The restricted trade has been a basis for our shipbuilding and ship repair yards, for the operation and maintenance of our port facilities, and for the training and employment of seamen needed in time for national emergency.

The fleet and facilities thus developed have played an important role in both peace and war. As late as the 1930's, large tonnages of lumber, canned goods, iron and steel products, and petroleum moved in this trade. On the eve of World War II, the coastwise and intercoastal trade was conducted through 259 ports—150 on the Atlantic, 30 on the Gulf of Mexico, and 79 on the Pacific. The fleet of 731 vessels employed in this service (612 in the coastwise and 119 in the intercoastal trades) in 1939 was requisitioned for use by the military forces to transport troops and material to the various theaters of operations. The service was interrelated with rail, motor, and pipeline transport, which acted as feeders or distributors between interior points of production or consumption and the seaboard.

Since World War II, neither coastwise nor intercoastal traffic has regained its prewar importance. The ships operating in this trade were returned to private ownership in mid-1947. The firms operating in the trade have since been handicapped by greatly increased operating costs and severe rate and service competition from railroads, pipelines, and trucks. Efforts have been made in recent years to reduce the very high costs involved in loading, unloading, and turnaround, by transporting loaded rail cars and highway trailers ("roll-on, roll-off" and "lift-on, lift-off") on general cargo ships. In addition, special types of containers and handling equipment are being developed. Nevertheless, rate reductions by other modes, made possible by new equipment and techniques of operation, an aggressive attitude, and by a more cost-

oriented regulatory philosophy, suggest that oceanborne domestic transportation is unlikely to regain its earlier importance in the foreseeable future. On the contrary, unless there are drastic reductions in shipbuilding and operating costs, the reverse is indicated.

Inland Water Transportation

The Great Lakes, St. Lawrence Seaway, and New York State Barge Canal as one unit and the inland river system together with canals, intra-coastal waterways and coastal rivers as a second unit form the two major categories of domestic water transportation. These waterways provide commercial water transport services to 38 of the 50 States, with 95 percent of the population, and to 81 of the 130 cities of 100,000 or more people.

The Great Lakes Complex

The five Great Lakes encompass an area of 95,000 square miles, a coastline of 8,300 miles, and approximately 70 commercial harbors bordering eight States. For a distance of 1,340 miles from Duluth, Minn., to Ogdensburg, N.Y., through a series of locks, there is a minimum channel depth of 21 feet, with some sections as deep as 27 feet. In addition, some 1,000 miles of this total is open water.

Large, specialized, and highly efficient lake steamers, designed particularly for the mass movement of mineral products and grain, shuttle back and forth continuously during the 8-month ice-free season and make the lakes the world's busiest waterway. Eastbound traffic is dominated by iron ore and grain movements. Pulpwood products and semi-processed raw materials also move in significant quantities. Westbound movements include coal, petroleum products, limestone, and smaller volumes of automotive vehicles, automotive parts, iron and steel products, and other manufactured items.¹

In 1959, as a result of a cooperative arrangement between Canada and the United States, the Great Lakes were made accessible to large, oceangoing ships through construction of the St. Lawrence Seaway. The primary importance of the seaway is in foreign trade; it only indirectly affects domestic commerce at the present time. As lake ports are enlarged and improved, however, rate and traffic patterns will change and the influence of the seaway on lake commerce will increase. Certainly the availability of this corridor for ocean transport penetration deep into the interior industrial and agricultural complex is a potentially valuable asset for defense as well as civilian commerce.

Although basically similar to inland river transportation, the New York State Barge Canal is an integral part of the total Great Lakes

¹ Roy J. Sampson and Martin J. Farris, *Domestic Transportation* (Boston: Houghton Mifflin Co., 1966), pp. 62, 63.

System. It connects Lakes Ontario and Erie with the Hudson River and Atlantic Ocean, using the main routes of the old Erie Canal which was so important in the early 1800's. The waterway was improved by the State of New York after 1903, but has since become somewhat obsolete compared to other inland waterways. The locks are small and the channel narrow, thus placing severe limits on the size of the tow that may be moved. The smaller the tow, the higher the unit costs of operation. Through improved service and reduced rates, railroads and trucks using the New York State Thruway have captured much of the former barge traffic. In addition, much of the industry that once used the waterway has relocated.

In 1959 the New York State Legislature authorized transfer of the canal to the Federal Government. Shipping interests favored the move, believing transfer would result in improvements. A joint legislative committee of the State, however, after a 4-year study, recommended retention. It is clear that significant capital investment is essential if the waterway is to regain its former status in the transportation picture of the region. Whether it would be economical to make such investments, however, is subject to dispute.

*Inland Rivers, Canals, Intracoastal Waterways and Port Channels**

Before the coming of the railroads, a large proportion of the Nation's transportation was conducted on inland waterways. They were the media for the inland expansion of colonial settlements and their main source of contact with the older towns along the coast. In the first half of the 19th century, following the appearance of the steamboat, the Ohio and Mississippi Rivers became the principal avenues of commerce in the Middle West. The period saw active concern with the improvement of the navigable waterways and the construction of canals.

With the emergence of the railroads about the middle of the 19th century, inland waterway traffic steadily lost ground. Railroad competition proved too keen for the steamboats and the era of canal building came to an end. Except for a slight revival after the Civil War, steamboating on the inland rivers declined rapidly and remained at a low ebb until the close of the century.

Early in the 20th century, a movement to revive inland water transportation took definite shape. Conservation of natural resources, rising railroad rates together with periods of congested facilities, sectional interests, and the ambitions of rival cities, were all factors which influenced passage of a series of legislative acts designed to aid inland

* An excellent source for information on this segment of water transportation is the American Waterways Operators, Inc., *Big Load Afloat* (Washington: The American Waterways Operators, Inc., 1966).

water transportation. As a result, in recent years this mode of transport, the oldest, has grown at a faster rate than all forms of commercial transport except air, the youngest. Approximately 10 percent of the total ton-miles of domestic commerce is now transported over improved waterways. The system over which the traffic moves includes in excess of 25,000 miles of usable, navigable channels, exclusive of the Great Lakes, and the total will increase significantly over the next few years. About one-third of the total miles are found in the Mississippi, Missouri, Illinois, and Ohio Rivers and their principal tributaries, the Arkansas, the Tennessee, and the Cumberland. In addition, there are extensive intracoastal waterways, including connecting rivers, canals, channels, and bays, along the Gulf and Atlantic coasts which permit almost continuous coastal navigation from New York to the Rio Grande River in Texas. Numerous smaller river systems, such as the Alabama-Tombigbee Black Warrior Rivers complex, connect interior cities with the coastal system. Figure 3 indicates the location of navigable waterways throughout the Nation. The standard operating depth for these channels is 9 feet, and at present approximately 60 percent of the total mileage meets or exceeds this standard. This condition is made possible by an extensive system of locks (particularly on the upper rivers) and continuous dredging by the Corps of Army Engineers. With the exception of the Upper Mississippi River, the Missouri River, and the New York Barge Canal (discussed as a part of the Great Lakes System), all the channels are open year round.

The barge and towing industry is comprised of some 1,700 companies with a total investment, exclusive of terminals and shore-based equipment and not including some 400 private carriers, estimated at \$1,450 million. The bulk of the capacity in service is modern in every way, major additions, replacements, and renovations having been made since World War II to meet steadily increasing demands. As an illustration, during the 1980's, the typical towboat (which in reality "pushes" a string of barges) had a powerplant in the 700 horsepower range; today, towboats with 9,000 horsepower are in service and 5,000-8,000 horsepower vehicles are common. Vessels with 6,000 or more horsepower operated by a crew of as few as nine men (compared to 30 after World War II and 15 5 years ago), are capable of pushing 40,000 to 50,000 tons of cargo in a string of 30-40 barges, a quarter of a mile long and 200 feet wide, at a steady 8-10 miles per hour (average speed, however, is about 4-5 miles per hour), 24 hours per day. In comparison, a railroad freight locomotive with 6,000 horsepower can efficiently pull a train of 120 cars loaded to an average of 50 tons each, or approximately 6,000 tons.

The barges in service are of many types. The "workhorse" is still the open hopper barge, the history of which dates back to the Revolutionary War period. The modern version has an average capacity of 1,500 tons with some units as high as 3,000 tons. Covered barges, tank barges, and special units, such as insulated, pressurized vessels for carrying cargo at extremely low temperatures, are also in service. With such equipment, the capability of the industry for moving bulk commodities is becoming ever more versatile.

Source: Transportation: The Nation's Lifelines, Industrial College of the Armed Forces, Washington D.C., 1968.

Channel Development

By reason of its very existence, located as it was — and is — the Ohio River provided an easy water highway to the west, serving to funnel the movement of settlers and of the country produce which soon sought a route to market.

The Ohio was easy, however, only when compared with overland routes, and especially the rugged and difficult roads across the Appalachians. As described in the historical preface of *The Ohio River*, issued by the Chief of Engineers in 1934:

In its original condition, the Ohio River was much obstructed throughout its entire length by snags, rocks, and gravel and sand bars, rendering navigation difficult and hazardous. The width of channel was exceedingly variable. The depth available for navigation over the worst shoals at extreme low water varied from a minimum of 1 foot between Pittsburgh, Pa. and Cincinnati, Ohio (470 miles), to 2 feet between Cincinnati and the mouth of the river (511 miles). When the depth over the worst shoals was 3 feet or more, the river was navigable throughout its entire length for steamboats and other craft, except as its use was affected by floods or ice.

Federal Aid to Inland Navigation

The first Inland Waterways Improvement Act, signed 24 May 1824 by President James Monroe, directed that experiments be conducted to determine the best method of coping with sandbars in the Ohio River and that measures be taken for the removal of snags obstructing navigation on the Ohio and

Mississippi Rivers. The Army Corps of Engineers was put in charge of this work, and three years later the Secretary of War was given the responsibility for supervising and directing improvements on all navigable waters.

The Chief Engineer of the Army established a public competition in June 1824 for the best "plan, machine, or instrument" for the removal of snags. Removal of snags and other obstructions was vitally necessary in protecting vessels against damage or loss, and, until construction of the slackwater system of navigation on the Ohio was begun in 1877, the use of cutoff dams on back channels and of wing dikes to concentrate flow in the main channels provided the principal means of improving the navigable depth. The wing dams, when adequately provided, were generally effective in assuring a minimum channel depth of 3 feet.

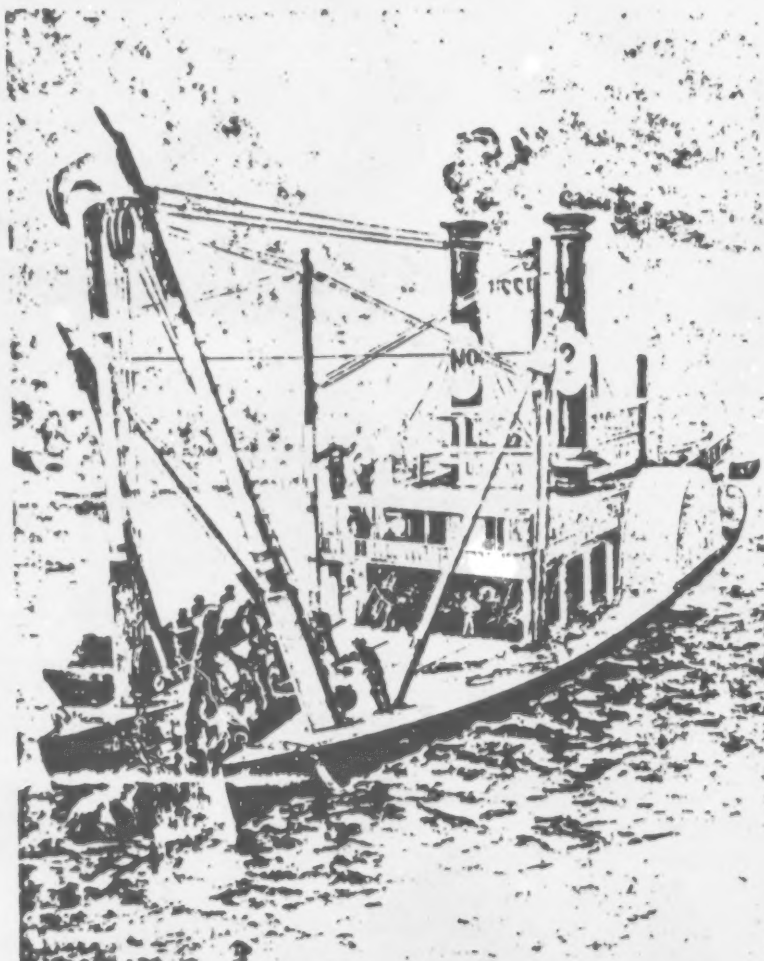
From 1826 to 1844 appropriations for the improvement of the Ohio were made with approximate regularity, but then, under contrasting political leadership, and during the Civil War, from 1845 to 1866, only two appropriations were made, one quite small, the other for \$95,000.

The first wing dam or training dike was begun at Henderson Bar in 1825. Removal of rocks from Grand Chain was begun in 1830. Dikes were begun at Scuffletown and Sisters Islands in 1831, and at French and Cumberland Islands, all downriver from Owensboro, Ky., in 1832. No work except snag removal was done above Louisville until 1836, when dams were begun at Brown Island. The success of these works was such that a large number of wing dikes and back channel dams were subsequently built between Pittsburgh and Cincinnati up until the general stoppage of work in 1845.

River traffic at Steubenville at an early period. From an old print



U. S. Snagboat No. 2, a single-hull, double-bow design. This was one of five snagboats for which Congress made provision in 1852. From Harper's Weekly, 2 November 1889



Channel Work Resumed

Marking a new era in the development of inland navigation, appropriations for improvement of the river were resumed in 1866. The work of open channel improvement has been continued as required from that time on.

Keeping the Channel Clear

Excerpts from the report of Colonel William E. Merrill for fiscal year 1888 will serve to exemplify the procedures and problems of channel maintenance and development on the Ohio before canalization. It shows that the snagboat *E. A. Woodruff* traveled the river 2,125-1/2 miles during the operating season, removing "1,225 snags, 127 large rocks, and 16-1/2 cubic yards of riprap, 46 new wrecks, and the remains of 13 wrecks, previously reported." One of the snags removed weighed 164 tons.

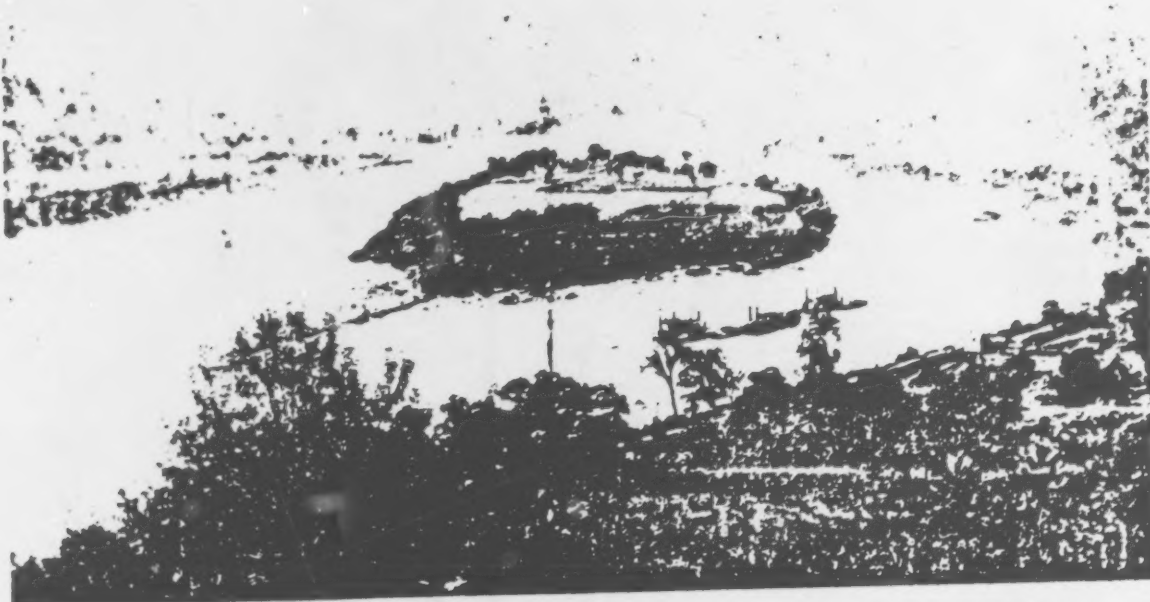
"Among the wrecks the most notable were those of

the wharf-boat at Huntington, W. Va.; the steamer *Jerry Osborn*, near Catlettsburgh, Ky.; the steamer *Good Intent*, at Lewisport (Ky.) Landing; the ferryboat, opposite Paducah, and the steamer *Charles Morgan*, from the harbor at the upper end of Cincinnati."

"During the summer and autumn of 1887 the Ohio River was continuously at a very low stage for the longest period ever known since regular gauge-records have been kept. During all this period of extraordinary low water the *Woodruff* was continuously at work, and was the only steam boat in commission on the river. She frequently had to spar her way over bars, and it took her four days to get over the bar at French Island; but she kept steadily at her work until she reached Cincinnati in the latter part of October. . . ."

"It was possible to have continued work above Cincinnati, but coal was at famine prices, and almost impossible to get at any price, and the occasion did not seem to call for unusual expenditures or risks."

The report also describes the work of Corps dredges



U. S. Dredges Ohio and Oswego at work at Three Brothers Islands, at about River Mile 158.4, 25 August 1887. A downstream view from Mount Dudley. The site of the present Willow Island Locks and Dam is in the distance

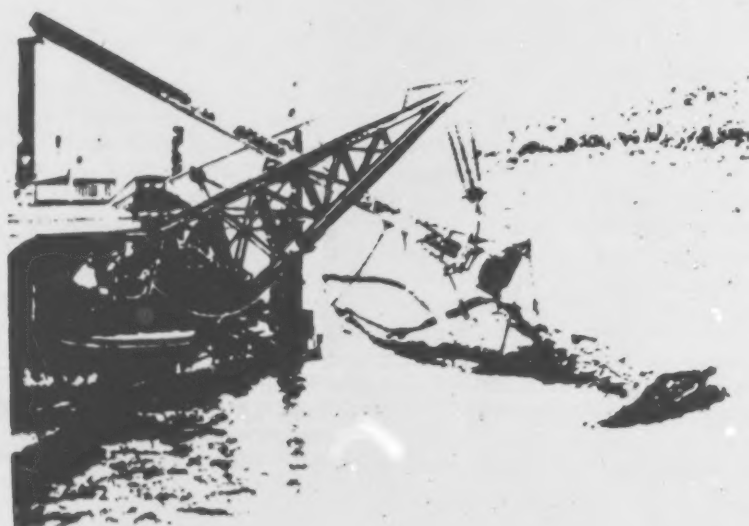
on the Ohio River in 1887, the work undertaken under contract for the removal of obstructions and in the building of dikes, and various problems of river development, all in considerable detail. Tabulations are also given on such subjects as the slope of the Ohio River at low water from Pittsburgh to Cairo, gage data, effects of ice on navigation, locations and status of dams and dikes, bridges over the Ohio, improvement contracts in force, statistics on river commerce, arrivals and departures of steamboats at Cincinnati,

commerce passing the Falls by canal and by river, and vessels passing the Davis Island Dam.

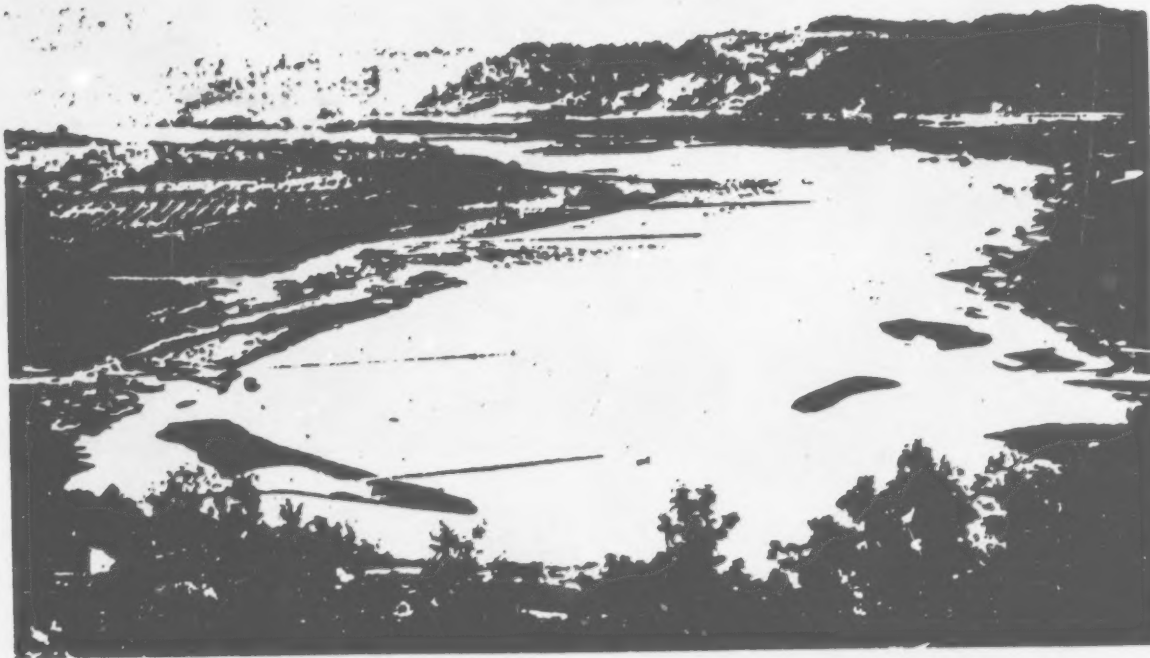
The report is representative of the annual Engineer reports issued in the period.

Channel Maintenance after Canalization.

Canalizing the river through the construction of locks and dams did not end the need for dredging.



An Ohio River snag being removed by a dredge in the 1885-93 period



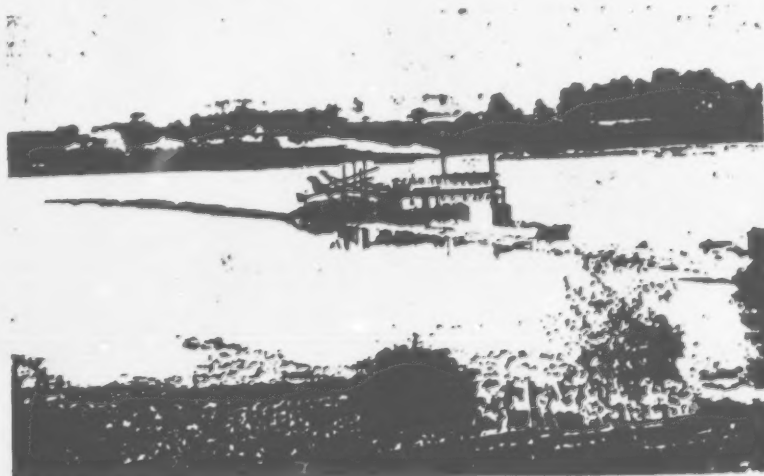
Ohio River as seen during a dry spell in the 1890s. The picture is an upriver view from the top of the hill (Seven Hills Farm) opposite Huntington, across from the former 26th Street ferry landing. Five stone training dikes show prominently. The two nearer at hand were built about 3 feet high, so the river stage may be taken at about 2 feet. Overlooking the river in the distance, left of center, is Proctorville, Ohio

River currents are constantly shifting sediments downstream, especially during floods, and shoals and bars are in constant process of relocation. Vessel movements also produce water movements which alter the configuration of the riverbottom.

To maintain channels for navigation, dredging is a continuing necessity. This is carried out by the Corps of Engineers primarily through contractors.

Open channel work on the Ohio River consists of removing obstructive bars and shoals areas within the various navigation pools to maintain a project operational depth of 9 feet and a minimum channel width of 300 feet as authorized for the present canalization system. The amount of material dredged depends upon the amount of sediment deposited in the channel during the high-water season and varies from season to

Dredges removing outer end of Rising Sun Dike (thirty-five miles below Cincinnati), September 1884



The Corps of Engineers suction dredge Ste. Genevieve, with barges, heading up the Ohio River near the mouth of the Scioto River at Portsmouth. Heading downriver is a tow of empty tank barges. At the right may be seen a portion of the Portsmouth floodwall



season.

Immediately following the construction of a dam there is a period during which little dredging is required within the new pool. Eventually the dredging requirements return, however, at least to pre-dam levels.

It is well understood that a prescribed navigable channel depth—of 9 feet for example—requires dredging to a depth greater than that specified, varying according to anticipated rates of sedimentation, potential pool fluctuation, and possible severe ice conditions. Otherwise, grounding of vessels would be a frequent occurrence—with resulting damage and delay—and emergency dredging and emergency recovery operations would become routine.

Charts and Navigation Aids

Navigation charts are issued annually by each of the Corps Districts, identifying the channel sailing line, mile points, locks and dams, bridges, underwater and

aerial pipeline and wire crossings, aids to navigation, river terminals, boat ramps, and industrial and other installations potentially affecting navigation.

Aids to navigation, including buoys, lights, and daymarks, are installed and maintained by the U. S. Coast Guard.



A vertical aerial view of a suction dredge clearing sand deposits from the Big Sandy River near Catlettsburg, October 1975. The dredged material is being pumped to a diked disposal area on low ground near by on the Kentucky side of the river. The disposal area became the site of the Catlettsburg pilot coal liquefaction plant, built under government sponsorship

LOWER MISSISSIPPI RIVER BASIN Memphis District

NAVIGATION PROJECTS UNDERWAY

The navigation projects currently underway in the State of Tennessee are limited to the western part along the Mississippi River, consisting of operations under the important continuing program for bank stabilization and dredging which is part of the Mississippi River and Tributaries, Alluvial Valley Project.

MISSISSIPPI RIVER AND TRIBUTARIES, ALLUVIAL VALLEY, NAVIGATION Cairo, Ill., to Baton Rouge, La. Lower Mississippi Valley Division

This project is a feature of the project, "Flood Control, Mississippi River and Tributaries," authorized by the Flood Control Act of 15 May 1928 and subsequent amendments (see "Flood Control Projects Underway"). In 1896, Congress authorized a channel 9 feet deep and 250 feet wide at low water between Cairo, Illinois, and the Head of Passes, Louisiana. In 1928, the authorized width was increased to 300 feet, and in 1944, the authorized channel depth from Cairo to Baton Rouge, La., was increased to 12 feet at low water, with the authorized width remaining at 300 feet. In this 725-mile reach, a low-water navigation channel 9 feet deep and 300 feet wide is maintained by dredging and training works. The low-water depth will be increased to 12 feet as the Mississippi River channel is stabilized. The closure of secondary channels by construction of sand fills and sand bar extensions (see Mississippi River Channel Improvement in the section "Flood Control Pro-

jects Underway") has resulted in increased efficiency of the main channel with an attendant lowering of navigation maintenance cost between Cairo and Baton Rouge, that at present involves dredging through some 60 to 100 crossings out of a total of about 200 during the low-water season. The number of crossings dredged and/or redredged and the volume of dredging required in any one low-water season is dependent largely upon the stage and discharge cycle, slopes, width of channel, velocities, alignment, and channel stability. The dredging required to maintain the 9-foot depth channel through these river crossings ranges from about 30 million to 70 million cubic yards annually.

Aids to navigation on the lower Mississippi River include fixed shore lights and markers, and buoys marking the navigation fairway. The total traffic on the river between Cairo and Baton Rouge, but not including Baton Rouge, during 1974 was 111,400,000 tons. The five-year average, 1970-1974, was 98,100,000 tons. The total traffic between Minneapolis, Minnesota, and the Gulf of Mexico in 1974 was 302,600,000 tons, as compared with an average annual traffic of 261,770,000 tons in this reach during the 10-year period 1965-1974.

A chart of the growth of Mississippi River traffic and a typical Mississippi River tow are shown on page 39.

A plate showing the freight movements on the entire Mississippi River system in 1970 appears on page 40.

Ohio Navigation as It Is Today

In three basic measurements the Ohio River Waterway of 1979 is the same as that of 1929. It is 981 miles long, its navigable depth is 9 feet, and its locks are 110 feet wide. But in fact, the Waterway has been greatly altered, to accommodate a tremendously increased volume of traffic.

The changes in the Waterway improvements have taken two major directions: (1) the replacing of the earlier low-lift lock and dam structures with a smaller number of high-lift structures with longer pools, and (2) the addition of 1,200-foot-long locks in the modern

projects to permit the expeditious passage of the longer modern tows, which could not be accommodated in a single lockage through the 600-foot-long locks which were the standard in 1929.

The progress which has been made in the modernization program may be seen from the accompanying table, which shows the Ohio River locks and dams as they are in 1979, with their River Mile locations, lock sizes, the years in which the locks were placed in operation, and the lifts—differences in elevation from one navigation pool to the next.

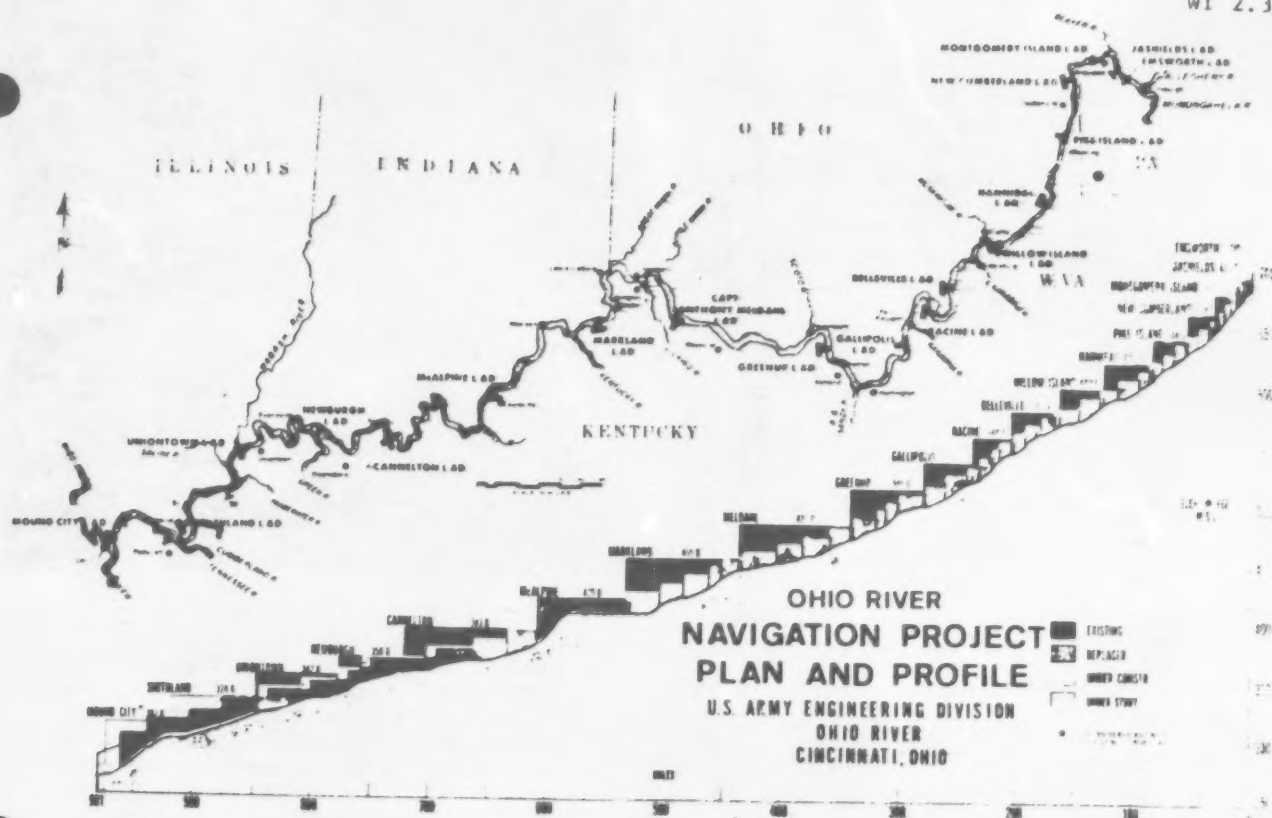
Ohio River Locks and Dams

1979

Ohio River navigation will be served by twenty lock and dam structures following completion of Smithland Dam (1980), when structures 50 and 51 will be removed

Dam Lock Designation	River Mile Location	Lock Sizes (in feet)		Years Locks Placed in Operation	Lift (in feet)
Emsworth	6.2	110 x 600	56 x 360	1921	18.0
Dashields	13.3	110 x 600	56 x 360	1929	10.0
Montgomery	31.7	110 x 600	56 x 360	1936	17.5
New Cumberland	54.4	110 x 600	110 x 1,200	1959	20.5
Pike Island	84.2	110 x 600	110 x 1,200	1963	21.0
Hannibal	126.4	110 x 600	110 x 1,200	1972	21.0
Willow Island	161.7	110 x 600	110 x 1,200	1972	20.0
Belleville	203.9	110 x 600	110 x 1,200	1967	22.0
Racine	237.5	110 x 600	110 x 1,200	1967	22.0
Gallipolis	279.2	110 x 600	110 x 360	1937	23.0
Greenup	341.0	110 x 600	110 x 1,200	1959	30.0
Meldahl	436.2	110 x 600	110 x 1,200	1962	30.0
Markland	531.5	110 x 600	110 x 1,200	1963	35.0
McAlpine	604.4	110 x 600	56 x 360 110 x 1,200	1921, 1930, 1961	37.0
Cannelton	720.7	110 x 600	110 x 1,200	1975	25.0
Newburgh	776.1	110 x 600	110 x 1,200	1969	33.0
Uniontown	846.0	110 x 1,200	110 x 600	1975	22.0
50	876.8	110 x 600		1928	10.0
51	903.1	110 x 600		1929	8.0
Smithland	918.5	110 x 1,200	110 x 1,200	1979	22.0
52	918.9	110 x 1,200	110 x 600	1969, 1978	12.0
53	962.6	110 x 600	110 x 1,200	1979, UC	13.4

UC = Under construction. Note: In the listing of lock sizes, the landward lock is listed in the first position.



The profile shows the locations of all the navigation structures ever built on the Ohio River

Locks and Dams on the Main River

In all, the Ohio River lock and dam system in 1979 comprises twenty-two lock and dam structures—two of these will be eliminated when Smithland Locks and Dam is completed early in 1980. There is also the Louisville and Portland Canal, markedly altered from its primitive form of 1830, when it was first opened to bypass the Ohio River rapids.

Fourteen of the 1979 navigation structures comprise the modernized portion of the Ohio River Waterway. All of these contain 1,200-foot locks, placed in operation between 1961 and 1979.

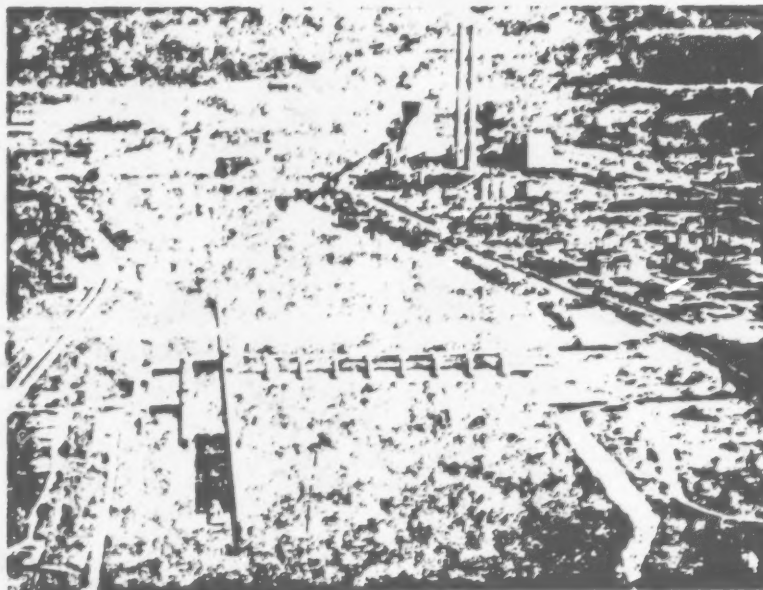
Four are named structures opened from 1921 to 1937 to replace original numbered structures. Each of these has two locks, but the larger lock in each case is 110 by 600 feet, which was standard in the original system. These four structures which are below present-day standards include the three nearest Pittsburgh—Emmsworth, Dashields, and Montgomery—and

Gallipolis Locks and Dam, at River Mile 279.2. The Gallipolis structure, completed in 1937 and the most modern on the river at the time, replaced three Ohio River and three Kanawha River lock and dam structures.

Four of the present dams—50, 51, 52, and 53—were part of the Ohio River system as originally constructed. Dams 50 and 51 will be removed in 1980 (following completion of Smithland Locks and Dam), while 52 and 53 will be retained in use pending later resolution of the navigation problems along the lower reach of the river. In the meantime, a new temporary 110- by 1,200-foot lockchamber has been added at 52, and a similar structure is under construction at 53.

Of the fourteen modern structures already referred to, thirteen were entirely new installations, complete with dam and 1,200- and 600-foot locks, each built to replace two or more of the original low-lift structures. At Louisville, however, a 1,200-foot lock was added, and the dam was modified, the normal level of the up-river pool remaining unchanged at 420 feet above sea level. The lift from the lower pool continued at 37 feet. Because of the rapids it had never been feasible to build a single low-lift dam at Louisville.

Willow Island Locks and Dam, completed in 1976. A chemical plant of American Cyanamid Company is on the West Virginia side of the river, and next upstream is the Pleasants steam electric generating station of Monongahela Power Company



Pattern of the Ohio River Navigation System

The Corps of Engineers maintains a navigation channel with 9-foot authorized depth on the Ohio River from Pittsburgh to the mouth (981 miles) and on some 1,300 miles of tributary streams. The major tributaries and their navigable distances are: Allegheny River, 72 miles; Monongahela River, 129 miles; Kanawha River, 91 miles; Green River, 103 miles (plus 46 miles of 5.5-foot depth upstream from Mile 103); Tennessee River, 652 miles; and Cumberland River, 385 miles. The Kentucky River is navigable for 259 miles, but the navigable depth provided is limited to 6 feet and the lockchambers are too small for the use of standard Ohio River barges. (The Muskingum River has a navigable depth of 5 feet for a distance of 93 miles, maintained for pleasure craft by the state of Ohio, but the lockchambers are too small for standard commercial barges.)

Volume and Character of Traffic Flow

To illustrate the traffic carrying function of the Ohio River and its canalized tributaries, a diagram is presented showing the traffic flow on the inland waterways and the Gulf Intracoastal Waterway. The

Great Lakes waterway, with its adaptability to the use of deeper draft vessels, is omitted from the diagram.

The character of Ohio River traffic has changed considerably. Since 1925 coal has comprised about half the total tonnage moved on the river. The other half formerly consisted principally of stone and sand and gravel, but it is now made up mostly of oil and gasoline, iron and steel, and chemicals.

Types and Sizes of Towboats

Towboats as now constructed have from one to four propellers, each driven by a separate diesel engine. Several towboats having four engines with a combined horsepower of 10,000 are now in operation; they are 190 feet long and 54 feet wide and have a draft of 8.6 feet. The cost of building vessels of this size has run to about \$3,000,000.

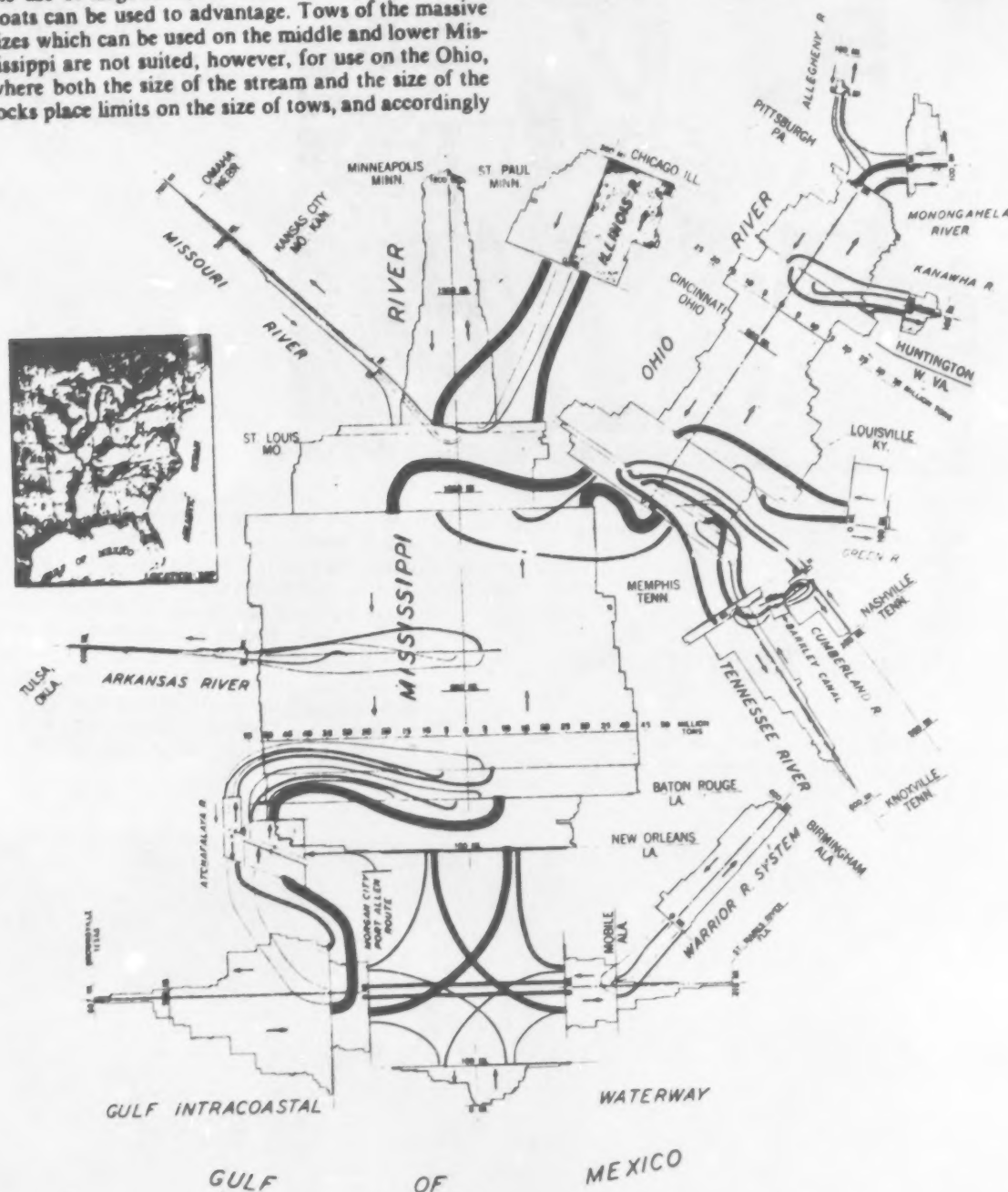
Three of the most common sizes of towboats now being built are:

Length	Width	Draft	Horsepower
117 feet	30 feet	7.6 feet	1,000 - 2,000
142 feet	34 feet	8.0 feet	2,000 - 4,000
160 feet	40 feet	8.6 feet	4,000 - 6,000

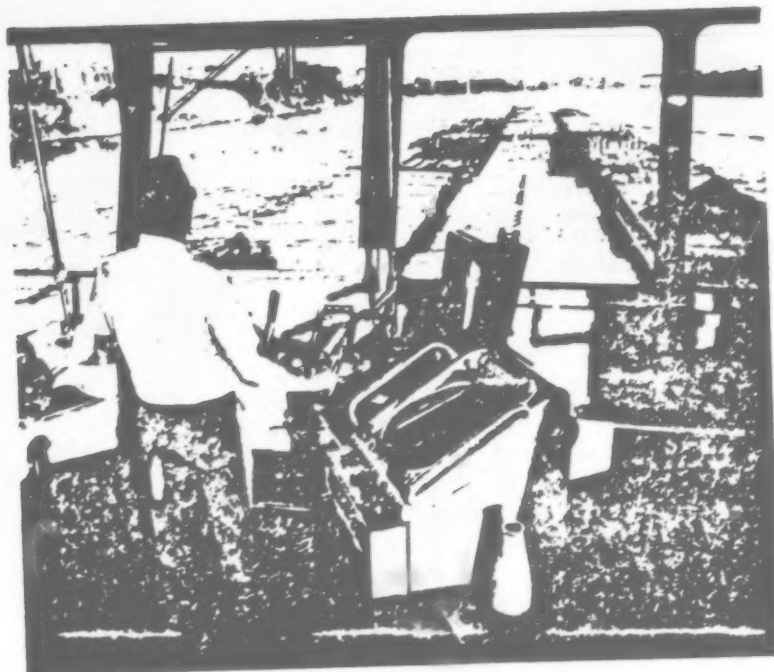
Towboats of 6,000 horsepower and more can push tows carrying 40,000 to 50,000 tons of cargo.

"The sizes of towboats are determined by the waterway on which they are to be operated and on the work they are expected to do. The broad and unobstructed Mississippi below St. Louis lends itself to the use of large tows, for which more powerful towboats can be used to advantage. Tows of the massive sizes which can be used on the middle and lower Mississippi are not suited, however, for use on the Ohio, where both the size of the stream and the size of the locks place limits on the size of tows, and accordingly

on the power of the towboats which can be employed effectively. Small towboats can be used for moving individual barges, for assembling or disassembling tows, and for a variety of harbor work. Some of these are no more than about 12 feet wide by 36 feet long, with 6-



INLAND FREIGHT TONNAGE ON THE MISSISSIPPI RIVER SYSTEM
AND THE GULF INTRACOASTAL WATERWAY 1973



Towboat Peace with down-bound tow, near Ashland, Ky., as seen from pilothouse. The pilot has many modern aids. Among the advances: elimination of the steering wheel

foot draft, and propelled by an engine of about 100 horsepower.

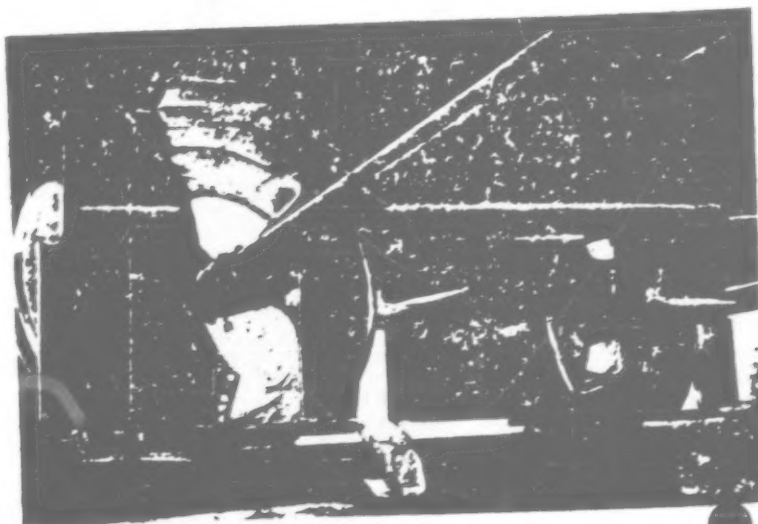
Towboat Improvements

A 1974 report showed that inland waterways tonnage tripled over a forty-year period. At the same time, the average length of haul increased from 50 to 375

miles. As a result the ton-miles of traffic generated increased twenty-two-fold. Crew size was cut in half during the forty years, however, and productivity per man was thus increased fortyfold.

The strides made in the waterways industry were made possible by the development and adoption of "the medium speed diesel engine, the Kort nozzle, the tunnel hull, radar, swing indicators, and telecommunications," the report indicates. It is pointed out, however, that "marine systems are now approaching the physical limitations of the inland waterways system."

Bottom of the tunnel stern of a river towboat, showing rudders, propellers and Kort nozzles



Types and Sizes of Barges

Four types of barges are employed: (1) open hopper, (2) covered hopper, (3) deck, and (4) tank. Based on a study of barges in use on the Mississippi River System and the Gulf Intracoastal Waterway, forty-seven type-and-size categories have been recognized, the size groupings being based on the lengths and widths of the barges.

Open hopper barges, which can be used for all types of bulk solid cargoes, dominate the field, accounting for 44 percent of the aggregate tonnage capacity of all barges operating on the inland waterways. Covered hopper barges account for one-fourth of the total ton-

nage capacity, and tank barges for 22 percent. Deck barges make up 8 percent of the combined capacity.

To improve the economy of barge transportation the hulls of the barges are shaped to reduce drag. In some cases, however, barges are built to be assembled into integrated tows. These barges, lashed together, form a tow presenting an underwater configuration similar to that which would be afforded by a single vessel. Such a design calls for continuous use of the barges in integrated arrangement, as a departure from this arrangement introduces a drag element greater than if the barges were individually designed to minimize friction. A barge built square on both ends for use in the middle of an integrated tow is particularly unwieldy to handle as a separate unit. The integrated tow design is especially adapted for the carriage of petroleum products and chemicals in tank barges.



OPEN HOPPER BARGES

TYPE	LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
STANDARD	175	26	9	1000
JUMBO	195	26	9	1000
SUPER JUMBO	250-290	40-52		2500-3000



COVERED HOPPER BARGES

TYPE	LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
STANDARD	175	26	9	1000
JUMBO	195	26	9	1000



INTEGRATED CHEMICAL AND PETROLEUM BARGES

LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
150-200	30-54	9	1000-3000



TOWBOATS

LENGTH FEET	BREADTH FEET	DRAFT FEET	HORSEPOWER
65-100	24-30	5-9	200-7000

Predominant barge and tow types. The towboat drawing shows plainly the towing knees used in pushing the tows. The pilothouse roof gives an indication of the electronic gear used, including radar and local and distant airwave communications

The Tennessean

perspective

• SECTION B • EDITORIALS • OPINIONS • POLITICS •

Sunday, March 2, 1980

Tenn-Tom Shockwaves To Hit Kentucky Lake

By NICK SULLIVAN
Tennessean Outdoors Editor

CONSERVATIONISTS are gearing up for what they believe will be a series of environmental clashes over Kentucky Lake in the aftermath of the opening of the Tennessee-Tombigbee Waterway.

With the opening of Tenn-Tom, scheduled for 1984, this sleeping giant of a lake will become one of the major shipping waterways of the world and conservationists predict the shockwaves of "the Big Ditch" will lap at the shores of Kentucky Lake for decades to come.

Among the feared shockwaves are:

- 60% of the upriver traffic now using the Mississippi River will use the Tenn-Tom;

- Among the commodities to be shipped on the waterway will be 1,415,000 tons of petroleum products annually;

- The transition of several Middle and West Tennessee counties from agriculture-rural toward industrial-urban;

- Industrial development, in-

cluding 14,000 new jobs and 31,000 new residents in Hardin County and 13,000 new jobs and 30,000 new residents in McNairy County as well as dramatic population increases elsewhere.

"The primary and secondary environmental impacts of this project could be just unbelievable," said Tony Campbell, executive director for the Tennessee Conservation League. "We believe the effects of the Tennessee-Tombigbee on Kentucky Lake will be the top environmental issue in Tennessee in the 1980s."

In an effort to ease the impact of the waterway on the Kentucky Lake region as well as the rest of the areas in its path, the U.S. Army Corps of Engineers has formed a series of committees known as the Tennessee-Tombigbee Corridor

Study to establish some long-range planning guidelines for state and local authorities.

"Tenn-Tom will have an effect on the Kentucky Lake area," said Phil Armour of the State Planning Office. "It may be good or it may be bad. One thing is sure, it will be big."

Kentucky Lake, created by the Tennessee Valley Authority on the Tennessee River in the early 1940s, stretches from below Pickwick Dam in southwest Tennessee to Kentucky Dam near the Ohio River in Kentucky.

Since its impoundment, it has remained primarily undeveloped. It has been a tourist lake, catering to fishermen, pleasure boaters and family vacationers. It is the winter home for an abundance of waterfowl which have found the sprawling Tennessee National Wildlife Refuge and adjoining flooded wetlands to their liking. Other migratory and non-migratory birds, including the great blue herons and the American bald eagle, inhabit or visit the lake.

WATER TRANSPORTATION FACTS

A tow of barges requires from 11 to 24 horsepower per 100 tons of cargo moved in all conditions. To carry the equivalent, it takes 175 railroad cars to move the same amount of tonnage. In fair weather on zero grade, that requires about 44 horsepower per 100 tons of cargo.

A river barge can carry almost five times its own weight. A rail car can carry about 1 1/3 times its own weight.

It takes about 14 man-hours to move 10,000 ton miles by rail. Water transportation for the same amount takes about 8 man-hours.

U.S. Department of Transportation figures show that the private investment in rail transportation per 1000 ton miles carried is \$32.30. This does not count the sizable public investment for certain railroads. For water transportation (including public investment for navigation improvements) the figures for 1000 ton miles carried come to \$6.84.

A railway tank car requires 1543 pounds of steel per ton of capacity; a river barge only 433 pounds.

In 1973 railroads were consuming about 4.7 gallons of diesel fuel for every 1000 ton miles carried.

For the same amount of cargo, inland water carriers were using only three gallons. More recent figures bring the total down to 2.6 gallons.

Trains and trucks carrying flammable fuels and toxic chemicals roar through the middle of towns and cities, causing noise and air pollution. Inland water transportation vessels move quietly on rivers and lakes, the noise of their engines muffled below the water line.

The Interstate Commerce Commission projects federal funding of railroad cars at \$3.6 billion. There has never been any federal funding for river barges.

(From Tennessee Market Bulletin, April 1977.)

USEFUL MARINE KNOTS

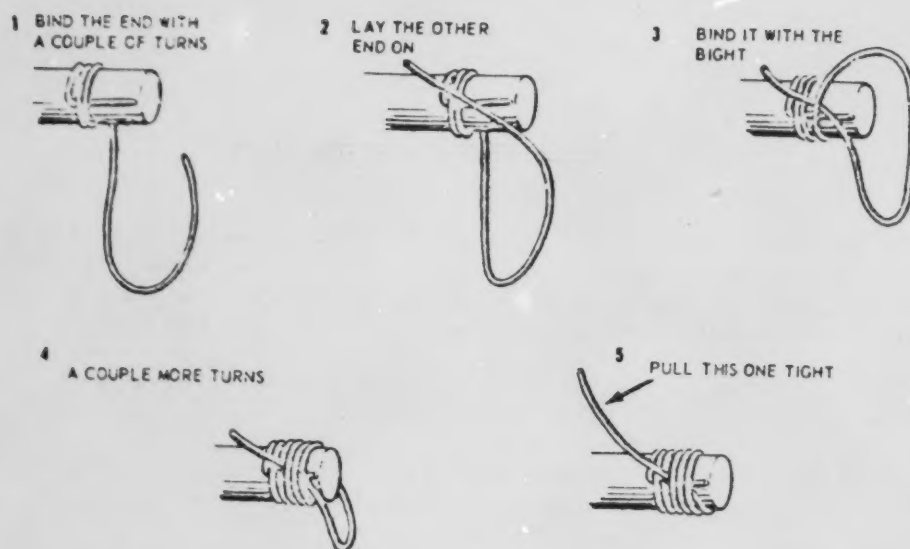


Figure 1.—Plain-whipping a line.

All Navymen are required to know the square knot, bowline, single and double becket bends, and the round turn and two half hitches and their uses. Knowledge of the clove hitch is not

required, but it is described here because it is an extremely useful hitch.

Before reading further, observe figure 2, which illustrates a few terms that make it easier

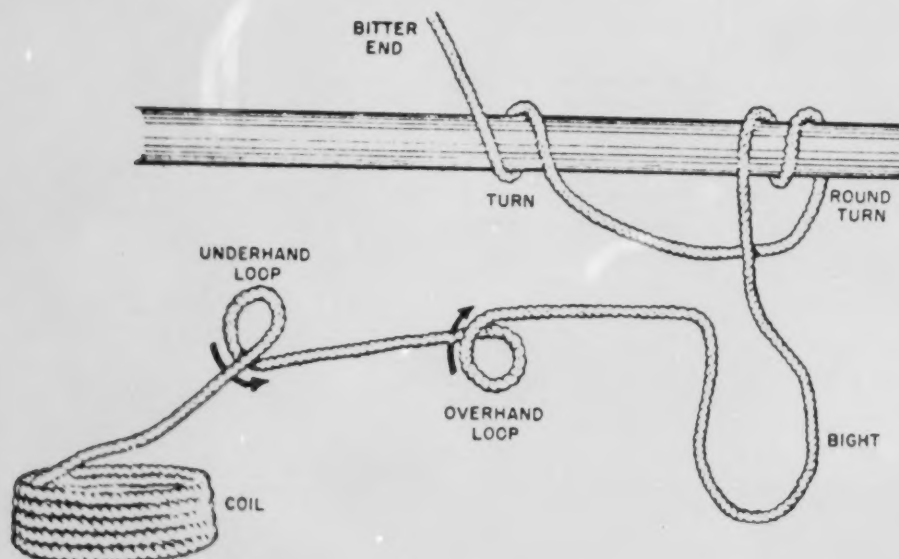


Figure 2.—Elements of knots, bends, and hitches.

for you to understand the following knot-tying procedures.

Square Knot

The square knot, also known as the reef knot from its use in reefing sails, is quickly and easily made and has a great many uses. It will not slip, but it can jam under heavy strain. It can be loosened, however, by pulling on first one and then the other end. Figure 3 shows steps in making a square knot.

Bowline

The bowline, with its many variations, is one of the most useful knots. Its chief use is to form an eye, but it also can be used to secure a line to a padeye or other ring, around a stanchion or other object, or to bend two lines together.

The easiest and most seamanlike method of making a bowline is shown in figure 4. Form a bight and grasp a single part of the line with the left hand, and both parts of the line with the right hand, as shown in view A. Turn the right hand down, pushing the bitter end through the bight (view A), then rotate the right hand palm up. With the left hand, form a small loop around the bitter end and grasp both parts of the line where the loop crosses the standing part (view B). Pass the bitter end around behind the standing part and down through the small loop (view B). Tighten the knot as shown in view C.

Becket Bend

The chief value of the becket bend is that it can be used to bend together two lines of

different sizes. If there is a great difference in sizes, or the strain on the line is to be great, always use a double becket bend.

To fashion a single becket bend, make a bight in one line and run the bitter end of the other line up through it as shown in figure 5. Pass the end around behind both parts of the bight and back under itself (second view). The third view shows how a double becket bend is made by simply taking another turn around the bight. (These bends are also known as sheet bends.)

Clove Hitch

The clove hitch can be quickly and easily tied in several ways, and it will hold as long as there is a strain on it. Once the strain is taken off, however, the hitch must be checked and tightened to prevent the bitter end from pulling out when the strain is reapplied. To make this checking and tightening unnecessary, many men lash a clove hitch with a half hitch around the standing part.

To tie this hitch (fig. 6) take a turn with the bitter end, pass the end across the standing part, and take another turn. (Notice that both turns go around in the same direction.) Now, pass the end under itself, and the hitch is complete.

Another way to make this hitch is to form two underhand loops. Lay the second loop on top of the first. This method is the usual way to form the hitch when it can be slipped over the end of the object to which the line is to be secured.

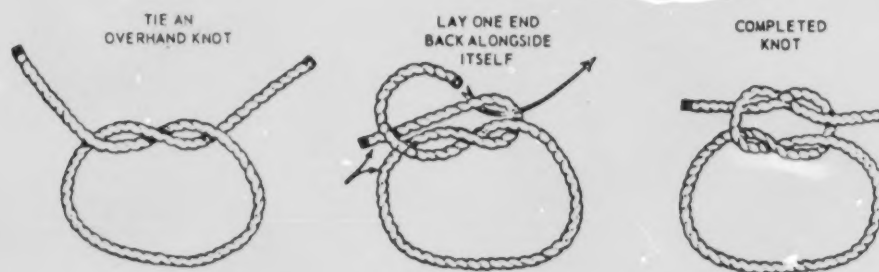


Figure 3.—Square knot.

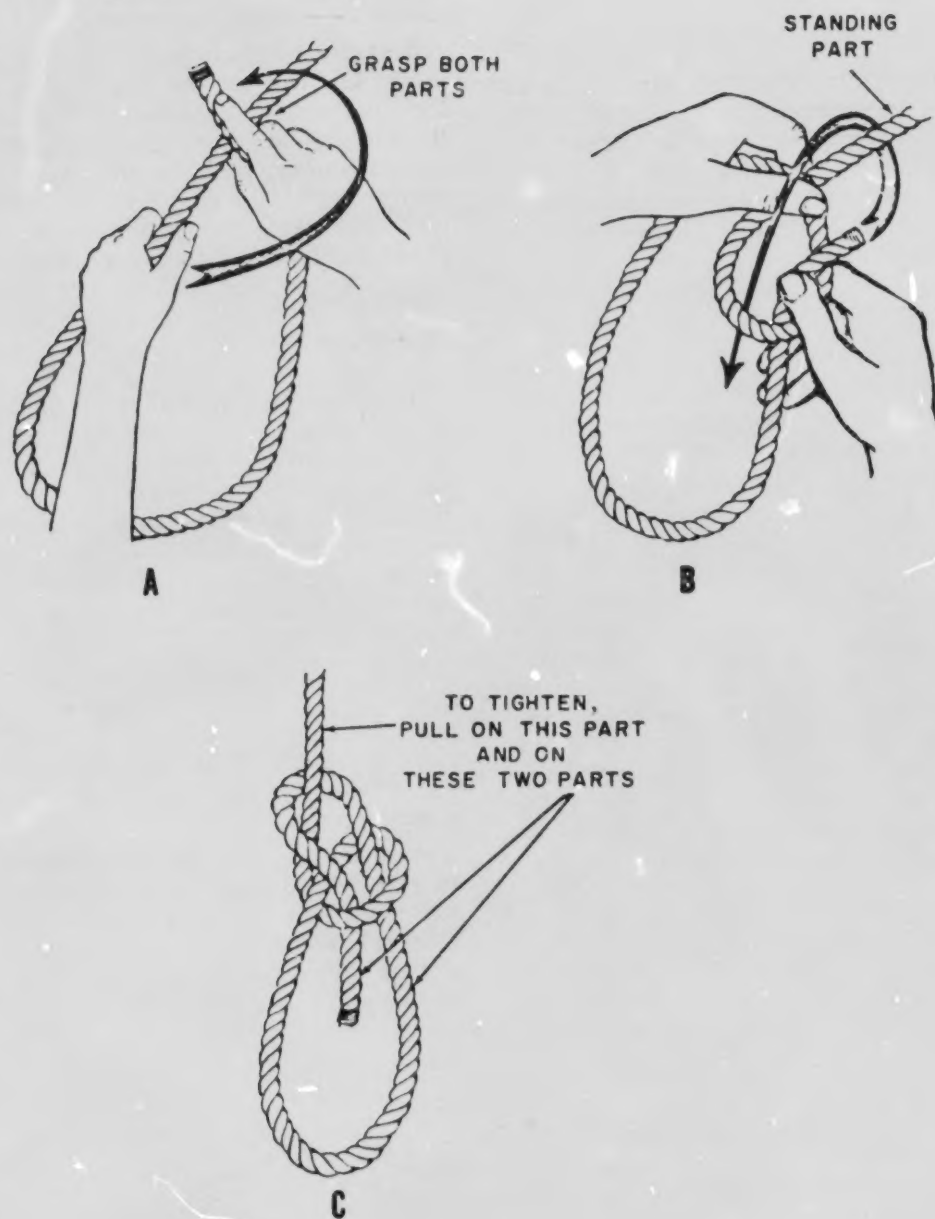


Figure 4.—Bowline.



Figure 5.—Single and double becket bends.

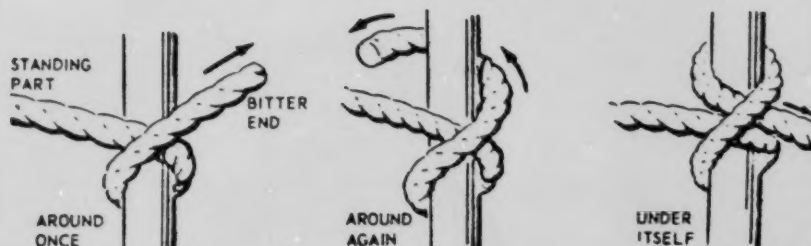


Figure 6.—Tying a clove hitch.

Round Turn and Two Half Hitches

The chief advantage of the round turn and two half hitches over other hitches is that it will not slip along the object to which it is secured, as might some of the other hitches. If the angle of pull is to be acute, therefore, always use this hitch. It is made by taking a round turn (fig. 7) and making two half hitches. (The two half hitches actually consist of a clove hitch taken around the line itself.)

7) and making two half hitches. (The two half hitches actually consist of a clove hitch taken around the line itself.)

SECURING FOR SEA

You are required to learn these knots, bends, and hitches so that you can use them when and where necessary. Rest assured that a man who goes to sea will find frequent use for them in securing equipment to prevent damage from

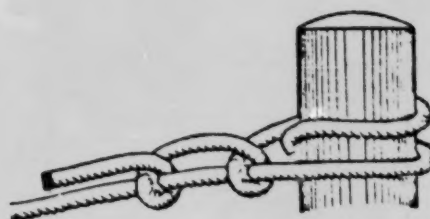
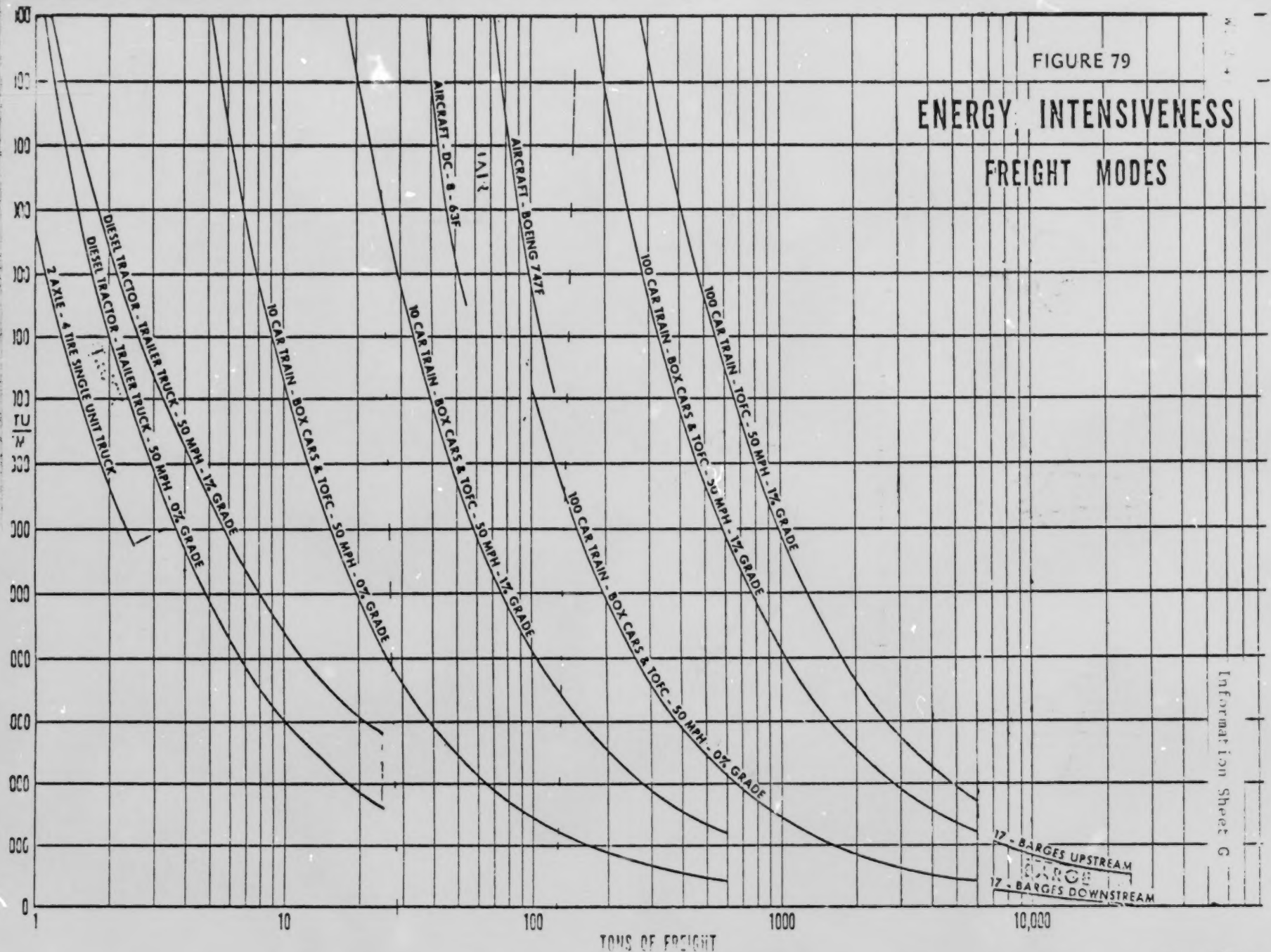


Figure 7.—Round turn and two half hitches.

rough waters. How the equipment is secured depends on the gear and the places of stowage. By observing the few tips that follow, and by using a little common sense, you should be able to do a good job of securing your equipment for sea.

FIGURE 79

ENERGY INTENSIVENESS FREIGHT MODES





675

676

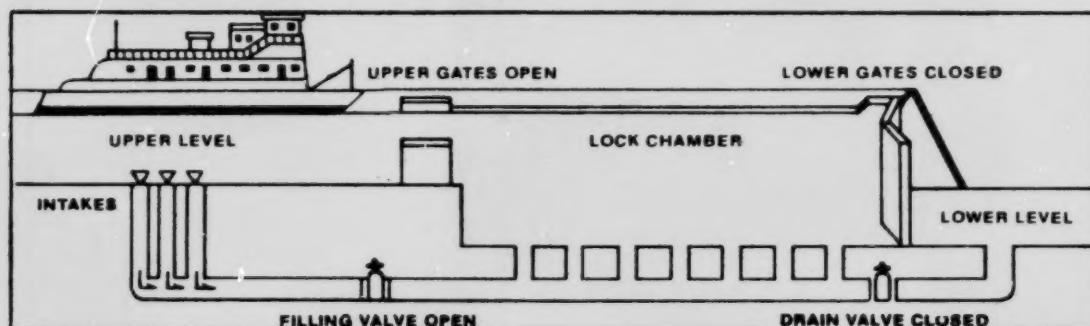
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How Navigation Locks Work

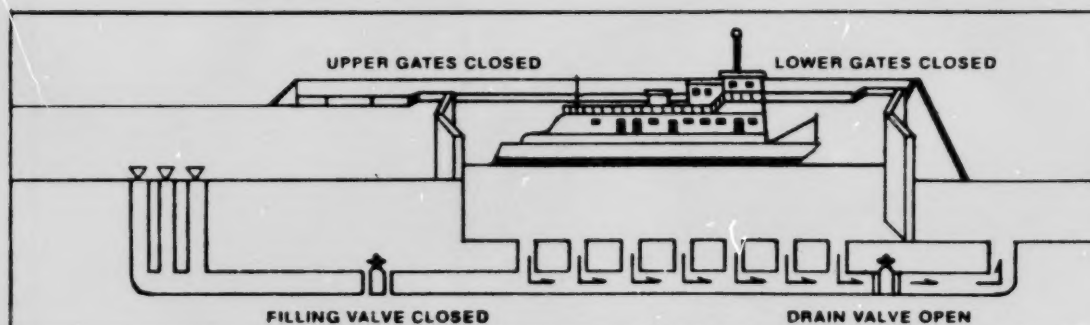
To provide adequate depth for navigation at all seasons, the Ohio River and major tributaries have been improved through the building of locks and dams. Each dam impounds a pool for navigation. The locks provide the means by which vessels are

raised or lowered from one pool to the next.

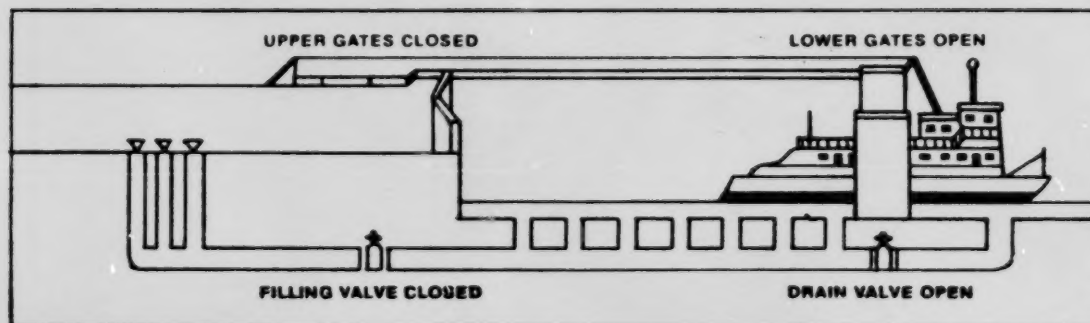
The accompanying diagrams show how locks function. A towboat is here being passed from the upriver to the downriver level.



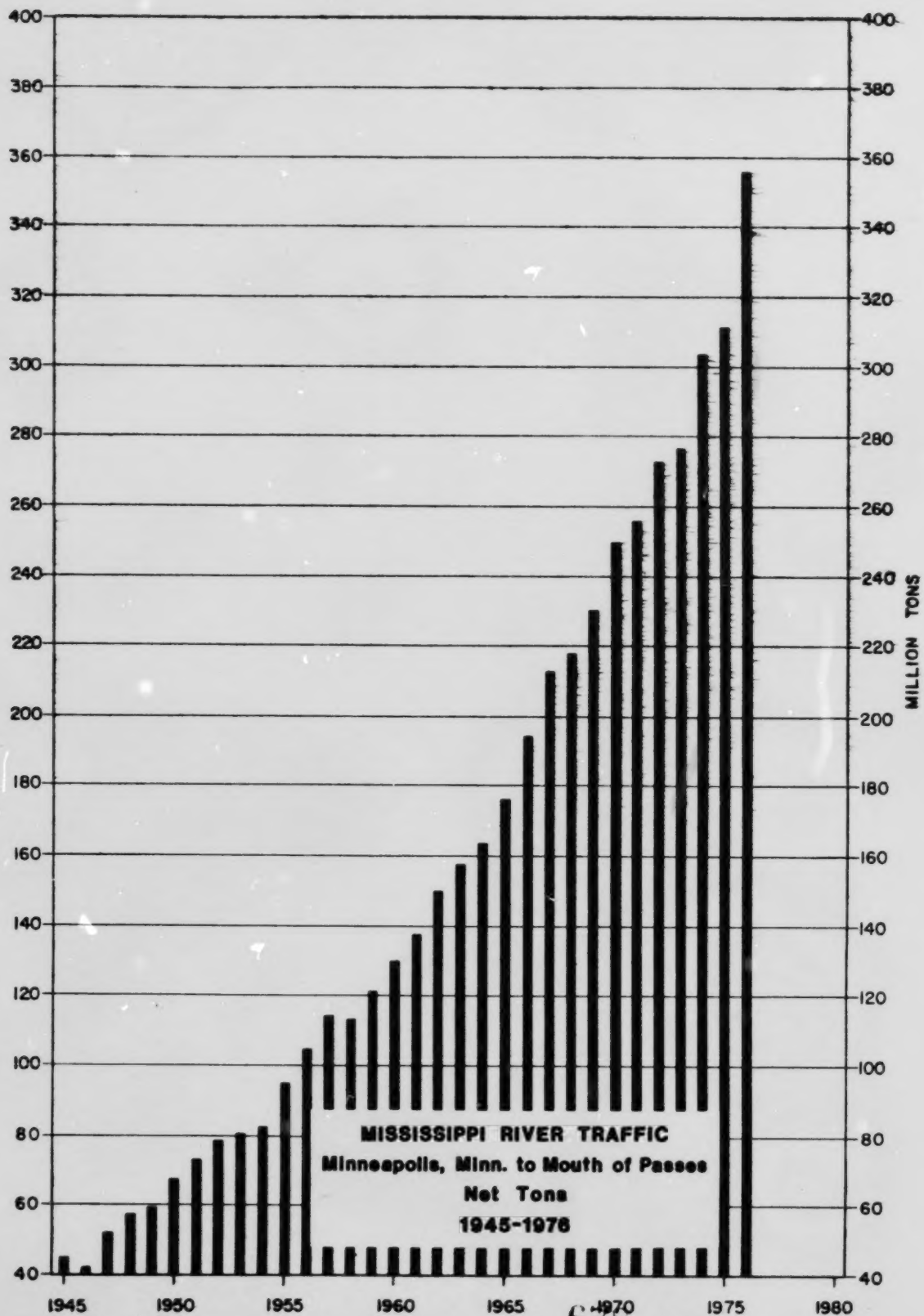
The lower lock gates are closed; the drain valve is closed; the filling valve is open; the lock has filled to the level of the upriver pool; and the upper lock gates have been opened to allow the towboat to enter the lock



Now the towboat is in the lock; the upper lock gates have been closed; the filling valve is closed; the drain valve is open, allowing water to drain into the downriver pool. The towboat is lowered as the water level lowers



The water in the lock has here reached the level of the downriver pool. The lower lock gates have been opened and the towboat is leaving the lock to proceed on its way downriver





River Transportation Division
Iowa Department of Transportation
6268 N.W. 2nd Avenue
Des Moines, Iowa 50313
515/281-4292

COMPARE

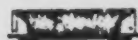
CARGO CAPACITY



BARGE
1500 TON
52,500 BUSHELS
862,600 GALLONS



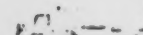
15 BARGE TOW
22,500 TON
787,500 BUSHELS
8,804,000 GALLONS



JUMBO HOPPER CAR
100 TON
3,500 BUSHELS
30,340 GALLONS

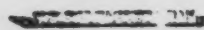


100 CAR UNIT TRAIN (GRAIN)
10,000 TON
350,000 BUSHELS
3,024,000 GALLONS



LARGE SEMI
25 TON
875 BUSHELS
7,360 GALLONS

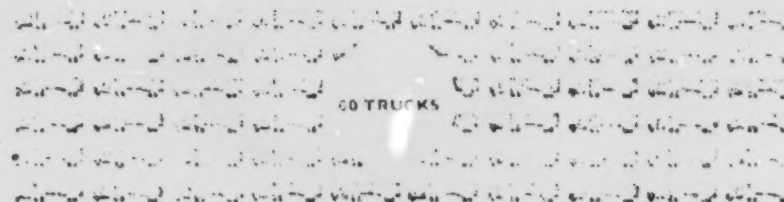
EQUIVALENT UNITS



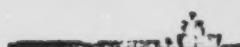
1 BARGE



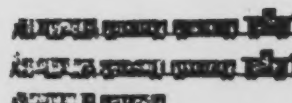
15 JUMBO HOPPERS



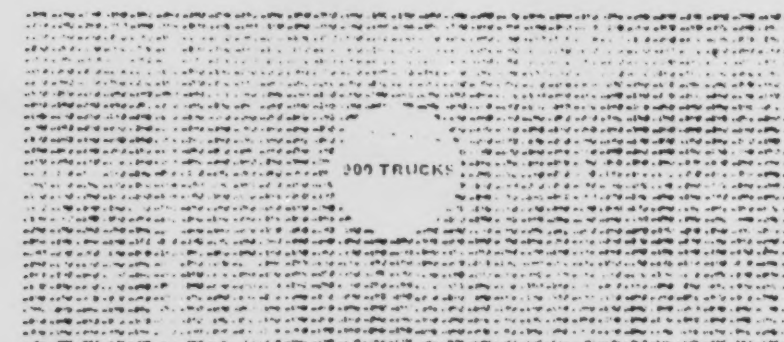
60 TRUCKS



1 TOW



24 UNIT TRAINS



300 TRUCKS

EQUIVALENT LENGTHS



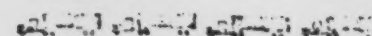
1 MILE

15 BARGE TOW



24 MILES

24 UNIT TRAINS



30 MILES

**ASSUMING 100 FT.
BETWEEN TRUCKS**

679

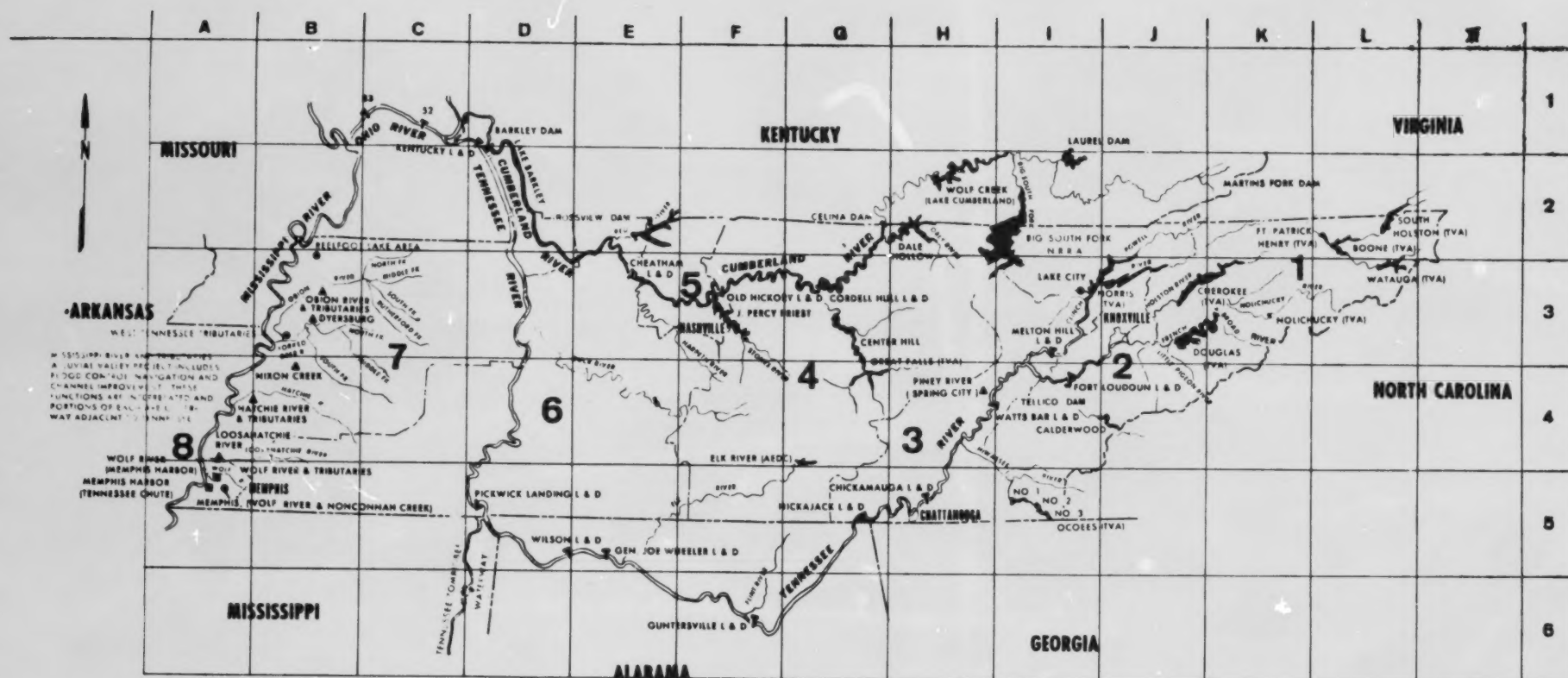
Prepared by:
Planning and Research Division

680

T.M.-4 / WT 2.42-D



The Ohio River Division of the U. S. Corps of Engineers includes all of Tennessee (shaded area) except the extreme eastern and western sections of the state.



LEGEND

	COMPLETED	UNDER CONSTRUCTION	NOT STARTED
RESERVOIR			
LOCAL PROTECTION			NONE
LOCK AND DAM			
HARBOR			NONE
OTHER IMPROVEMENTS			NONE
PROJECTS CONSTRUCTED BY OTHERS			
CONGRESSIONAL DISTRICT			6

NOTES:

TENNESSEE RIVER PROJECTS ARE CONTROLLED BY TVA. THE CORPS OF ENGINEERS IS RESPONSIBLE FOR OPERATION AND MAINTENANCE OF NAVIGATION FACILITIES ONLY.

LOCATION OF EMERGENCY REPAIRS, EMERGENCY BANK PROTECTION, FLOOD PLAIN INFORMATION STUDIES, BRIDGE ALTERATIONS AND SURVEYS ARE NOT SHOWN.

OTHER IMPROVEMENTS INCLUDE PROJECTS UNDERWAY OR COMPLETED THAT ARE CLASSIFIED AS WORK UNDER SPECIAL CONTINUING AUTHORITIES. SMALL FLOOD CONTROL PROJECTS, SHOULDERING AND CLEARING PROJECTS.

WATER RESOURCES DEVELOPMENT

OF THE
U.S. ARMY CORPS OF ENGINEERS

IN
TENNESSEE

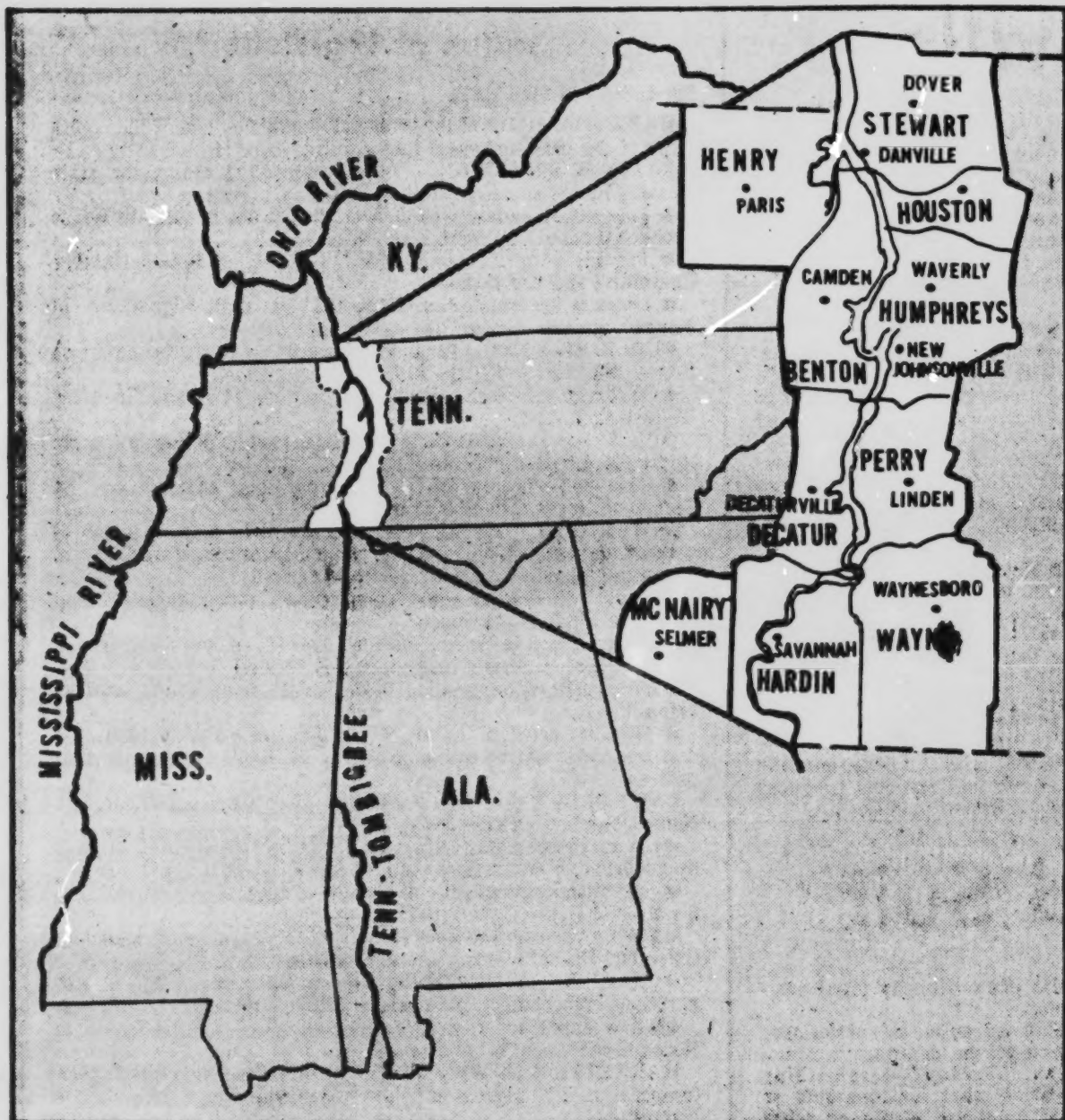
SCALE 100 MILES

1 JANUARY 1970

T.M.-6 / WT 2.42-P

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683



—Staff map by Jim Young

This map shows the route of the Tennessee-Tombigbee Waterway from the Gulf of Mexico to the Ohio River. The inset shows the area of Tennessee around Kentucky Lake which will be most affected by development according to planners.

LOCATING U. S. INLAND WATERWAYS



Match the names of these inland waterways with the corresponding numbers on the above map.

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.
- _____ 7.
- _____ 8.
- _____ 9.
- _____ 10.
- _____ 11.
- _____ 12.

- A. Ohio River
- B. Mississippi River
- C. Tennessee River
- D. Missouri River
- E. Snake River
- F. Yukon River
- G. St. Lawrence River
- H. Lake Erie
- I. Lake Huron
- J. Lake Michigan
- K. Lake Ontario
- L. Lake Superior

WT 2.44

ANSWERS TO STUDENT ACTIVITY SHEET #1

1. B
2. A
3. C
4. D
5. E
6. F
7. L
8. J
9. I
10. H
11. K
12. G

STUDENT ASSIGNMENT SHEETS #2 AND #3

Building a towboat and barge

Reference:

Information Sheet C.

Materials:

1 piece of economy grade 2 x 4 - 24" long for each student

10d box nails

Tools:

Claw hammer

24" bench rule

Rip saw

Coping saw

Jack plane

Spoke shave

Procedure:

1. Refer to Information Sheet C for towboat and barge sizes and types.
2. Select type of barge and size of towboat you plan to build.
3. Sketch top and side views on graph paper to scale to fit material.
4. Draw side and top views of barge and towboat to scale. (Use metric or English measurements as directed.) Get instructor to approve them.
5. Cut out drawings and trace on to wood.
6. Cut out wooden shapes, sand, and smooth.
7. Assemble towboat as required.

STUDENT ASSIGNMENT SHEET #4

Knot Tying

Reference:

Information Sheet F

Material:

3 foot length of 1/4" sisal rope for each student.

Procedure:

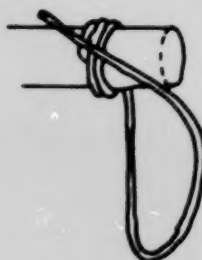
1. Whip ends of rope.
2. Tie each of the knots shown in reference and get instructor's approval on each.
3. Practice each knot until you can tie them from memory.

(NOTE: You may want to develop some competition and see who can tie all the knots in the fastest time.)

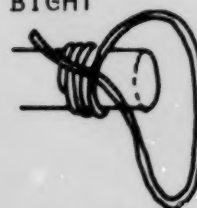
1 BIND THE END WITH
A COUPLE OF TURNS



2 LAY THE OTHER
END ON



3 BIND IT WITH THE
BIGHT



4 A COUPLE MORE TURNS



5 PULL THIS ONE TIGHT



FIGURE 1. - PLAIN-WHIPPING A LINE

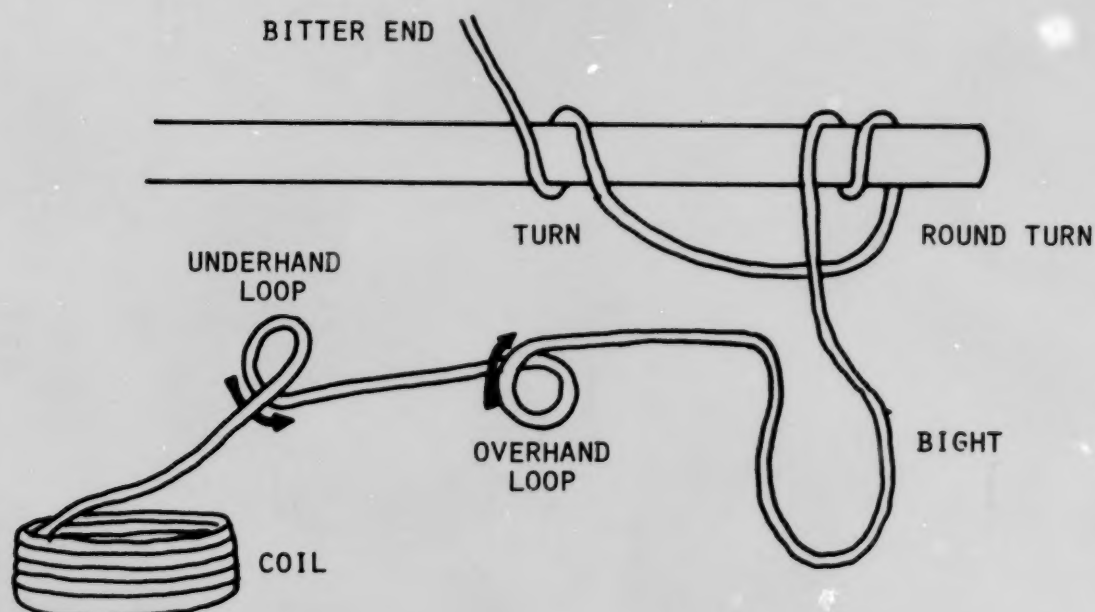


FIGURE 2. - ELEMENTS OF KNOTS, BENDS, AND HITCHES.



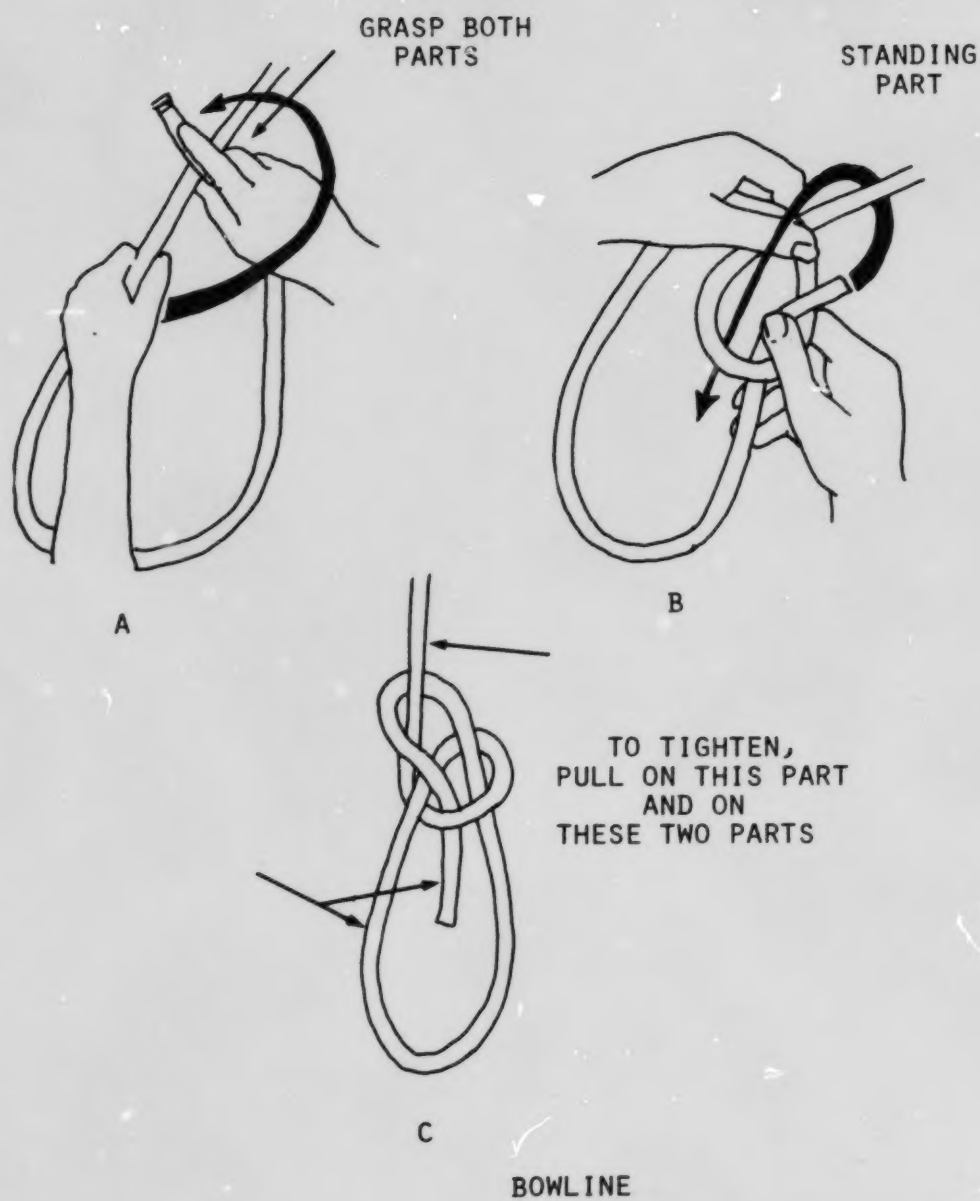
LAY ONE END
BACK ALONGSIDE
ITSELF



COMPLETED
KNOT



FIGURE 3. - SQUARE KNOT.



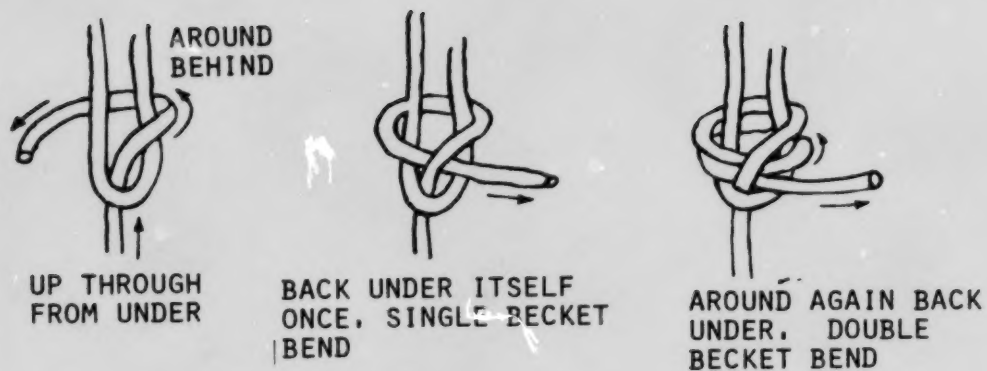


FIGURE 5. - SINGLE AND DOUBLE BECKET BENDS.

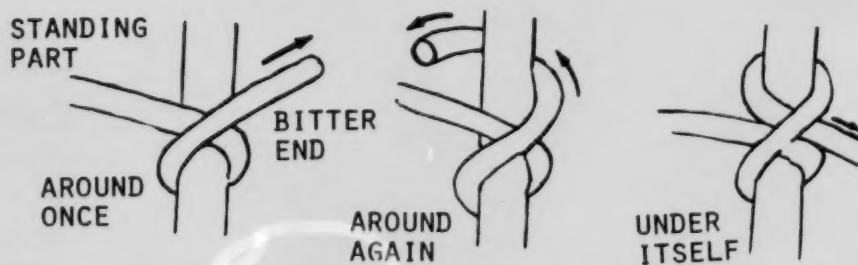


FIGURE 6. - TYING A CLOVE HITCH



FIGURE 7. - ROUND TURN AND TWO HALF HITCHES.

CLASS/GROUP ASSIGNMENT

Building a River/Lake Lock System

Reference:

Transparency Master #2

Materials:

As required

Tools:

As required

Procedure:

1. Review how lock system works.
2. Group students into group of 4 maximum.
3. Each group brainstorm on how to build a lock to fit towboat and barges built in assignments #1 and #2.
4. If a navigation lock is nearby, plan a field trip there to observe operation.
5. Each group makes presentation to class and class votes on best plan.
6. Best plan is then further detailed (working drawings) so it can be constructed and the necessary parts manufactured.
7. Proceed with lock construction as a class. Have groups assigned to build different parts to be transported to site and constructed.

UNIT TEST

On the map of the U.S. below are letters by waterways.

Identify each by name. (3 points each)



- A. _____
- B. _____
- C. _____
- D. _____
- E. _____
- F. _____
- G. _____
- H. _____
- I. _____
- J. _____

Listed below are several types of watercraft used on inland waters.
Place them in the proper sequence as when they were developed and used.
(3 points each)

K. _____ flatboat and keel boat

L. _____ canoe

M. _____ towboats and barges

N. _____ steam boats

PERFORMANCE TESTS

1. Sketch a front and side view (basic shape) of a modern tow boat.
(15 points)
2. By sketches and steps of procedure, tell how a lock operates to get
a towboat from a lower to a higher level. (30 points)

ANSWERS TO TEST

- A. Mississippi River
- B. Ohio River
- C. Mississippi River
- D. Snake River
- E. Intercoastal Waterway
- F. Lake Superior
- G. Lake Michigan
- H. Lake Huron
- I. Lake Erie
- J. Lake Ontario
- K. 2
- L. 1
- M. 4
- N. 3

Performance Tests

To instructor's satisfaction.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

T
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Instructional Section:

WATER

Title of Unit:

OCEAN TRANSPORTATION

DESCRIPTION OF UNIT

This unit will cover types of oceangoing vessels, their construction and development, trade routes, and technical job opportunities related to ocean transportation and its shore support activities. The materials in this unit are designed for 30 hours of instruction, but could readily be expanded to 45 or 90 hours by varying the activities.

UNIT OBJECTIVE

After completion of this unit the student will be able to identify terms and definitions relating to ocean transportation, list and describe the construction of various types of oceangoing vessels, demonstrate the ability to design and construct models of an oceangoing vessel and/or shore support facilities and/or equipment. This knowledge will also be evidenced by scoring 80% or better on the unit test.

PERFORMANCE OBJECTIVES

After completion of this unit, the student will be able to:

1. Match given ocean transportation terms to the correct definition or description.
2. List and describe the basic types of ship designs that haul cargo.
3. Identify the main parts of a ship.
4. Demonstrate the ability to construct one of the following:
 - a. Model bulk freighter cargo ship, tanker, or containerized cargo ship
 - b. Model port facility (warehouse, warf, pier, crane, rigging)

WT 3.2

5. Participate in a class project of designing (drawing) a typical sea port to include ship channels, berthing, loading and unloading facilities, and breakwater.
6. Demonstrate the mechanical advantages of various types of riggings.
7. Explain the importance of ocean travel and identify various types of navigation.
8. List a minimum of 4 technical jobs related to ocean transportation and supporting shore facilities.

OUTLINE OF CONTENT

I. Oceans

A. General Information

1. Eighty percent of world is covered by water.
2. Certain areas of the ocean have weather patterns that affect shipping. (TM #1) (TM #2)

B. Major Trade Routes (TM #3)

1. Vital transportation lines cross all oceans.
2. Freedom of seas essential to trade.
3. The U.S. had at one time the largest fleet but it has been passed by other countries because U.S. costs are higher. (TM #4)
4. Port Facilities (TM #26)

II. Ocean Transportation (Information Sheet #1)

A. Definition of Terms

1. Tonnage--Cargo carrying capacity, cubic capacity, or weight of cargo a ship can carry.
2. Cargo--Two categories.
 - a. Dry--bulk, general, heavy lift, deck
 - b. Liquid--petroleum, vegetable oils, animal oils, coal oils
3. Deck--A platform forming parts of the ship's guides going horizontally across a ship. (TM #7)
4. Hold--Name for space below deck where cargo is stored. (TM #14)

B. Basic ship construction--Ship's basic structure. (TM #20)

1. Hull (TM #5)
2. Superstructure (TM #6)
3. Deck numbering (TM #7)
4. Divisions of a ship (TM #7)
5. Ship lights (TM #8)

- C. Types of Merchant Ships (TM #10, 11) (Information Sheet #2)
 - 1. Combination passenger and cargo
 - 2. Freighters
 - 3. Bulk carriers
 - 4. Tankers
 - 5. Ocean tugboats (TM #9)
 - 6. Military support ships for the (Man-O-War ships) are similar to ship types 1 through 5.
 - 7. Multipurpose ships
- D. Cargo Handling
 - 1. Storage terms (Information Sheet #3) (TM #12, 13, 14)
 - 2. Booms and rigging (Information Sheet #4) (TM #17, 18)
 - 3. Rigging tackle (Information Sheet #5) (TM #16, 19 through 23).
 - 4. Cranes (Information Sheet #6)
 - 5. Special gear (Information Sheet #7)
 - 6. Containerization (Information Sheet #8)
 - 7. Cargo storage (Information Sheet #9) (TM #15)
- E. Transportation of People (Information Sheet #10)
 - 1. Because of time, few people travel by ship except for vacation type pleasure cruises.
 - 2. Some passenger spaces are available on cargo ships. (See Information Sheet #2)

III. Navigation (Information Sheet #11) (TM #24, 25)

- A. Bearings
- B. Charts
- C. Electronics devices
- D. Celestial
- E. Canals (Information Sheet #12)
 - 1. Panama Canal (locks)
 - 2. Suez Canal (no locks)

TEACHER ACTIVITIES

1. Hand out information and assignment sheets.
2. Make transparencies.
3. Discuss material in outline of content and insert activities at your discretion.
4. Administer tests.
5. Supervise design and construction activities.
6. Plan and coordinate field trips or guest speakers.
7. Procure map and film catalogs and order and schedule films at your discretion.
8. Contact other school teachers (history-geography-math) and ask their assistance in coordinating material in this unit.

STUDENT ACTIVITIES

1. Read and complete information and activity sheets.
2. Participate in class/group activities.
3. Complete assignment sheets given.
4. Take tests.
5. Perform the necessary design and construction activities assigned.
6. Go on field trips.

REFERENCES/RESOURCES

References:

1. Walker, John R. Exploring Power Technology (Basic Fundamentals)
Goodheart Wilcox, 1976.
2. Gilmer, Thomas C. Modern Ship Design U. S. Naval Institute,
Annapolis, MD, 1970.

Resources:

1. Additional information is available in the following Navy
training manuals:

Military Sea Transportation Service
Boatswain's Mate l&C
Mathematics Vol 1
Naval Orientation
Quartermaster l&C
Basic Military Requirements
2. Catalog of Nautical Charts
Defense Mapping Agency
Hydrographic/Topographic Center
Washington D.C. 20315
3. U.S. Navy Films for Public Use
Office of Information
Department of Navy
Washington, D.C. 20350

Ship Construction

Ever since people have gone down to the sea in ships, ship construction has employed a lot of people as shown in the pictures on the next pages.

A. Major Factors to be Considered in the Construction of Any Ship

1. Mission--Purpose for which ship will be used.
2. Protection--Features which help minimize or reduce the effects of damage from enemy attack.
3. Seaworthiness--Ship's ability to operate in all kinds of wind, weather, and seas.
4. Strength--Ship's ability to resist "breaking up" in stormy seas as it bends and twists.
5. Stability--Ability of ship to return to an upright position when tipped to one side by wind or waves.
6. Maneuverability--Ability of ship to change direction quickly and to turn in a sharp circle.
7. Cruising range--Also called endurance, the distance a ship can travel in nautical miles, without being resupplied with food, fuel, and water.
8. Habitability--Those features added for the comfort of the personnel manning the ship.

B. Stages in the Design of a Ship (NOTE: There are drawings at each stage getting more and more complex at each stage.)

1. Inception--The number and types of ships are determined. This may include modernization as well as new construction. Feasibility studies are made and ship characteristics are developed.
2. Conceptual design--Ship engineers prepare a set of drawings and information sheets showing principal features of basic design. Dimensions are selected and a model is constructed and tested for major factors.
3. Contract design--Every element (part) of the completed conceptual preliminary design is checked, refined, and redrawn in greater detail which become a part of the contract to build the ship.
4. Working drawings--When a ship builder has signed a contract, they, or a design agent they hire, prepare the working drawings from which the ship will be built.

C. Basic Ship Structure (TM #20)--A Ship is Structurally a Box Girder

1. Shell or plating--The outer layer of plating that forms the sides and bottom of the ship.
2. Keel--A strong I beam on the bottom of the ship that runs from stern to stern of the ship at the center line. (NOTE: The keel varies from 2 to 7 feet high depending on size of ship.)
3. Framing--Two types
 - a. Transverse--Frames that extend from keel outward and bend up to make the sides of the ship like ribs on a person. Plating is fastened to them at right angles to the keel.
 - b. Longitudinal (stringers)--Frames that run parallel to the keel. Plating is fastened to them.

D. Protective Systems Used in Ships

1. Inner bottom--A second "floor" in a ship that is watertight to protect against flooding if the outside shell gets broken.
2. Bulkheads--The name for "walls" in a ship. They support the various levels of a ship and give it strength. They can also be watertight to limit flooding.
3. Bents--Upside down "U" shape beams that are used to support decks that carry heavy loads.
4. Decks--The name for "floors" in a ship.
5. Compartmentation--Dividing the ship space into small "rooms" for passengers or cargo.
6. Watertight integrity--The ability of any part of a ship to keep the water out.

E. Shipbuilding Procedure--The Actual Procedure May Vary Widely but the Primary Operations are Similar

1. Construction site
 - a. Drydock or sloping concrete ways--So ship will slide into water when it is launched.
 - b. Blocks that make up the ways are high enough so people can get under the ship to build it.
 - c. A wooden cradle is shaped in the form of the shell of the ship to support its weight as it is being built.
 - d. Scaffolding is raised along the side as the hull is constructed.

2. Sub-assembly bays

- a. Modern practice is to build large portions of the ship at a location some distance from the building site.
- b. Large gantry or "whirly" (helicopters) cranes carry the sub-assemblies to construction site. (NOTE: Some sub-assemblies may weigh as much as 50 tons.)

3. Erecting the ship (pre-launching)

- a. Placing the keel on the blocks is the first step in building a ship.
- b. Ships and subassemblies are generally built from the center to the outside and forward and aft at the same time from the center of the keel.
- c. As soon as the double bottom and propeller struts (supports) are in place, the main propulsion, major auxiliary machinery and shafting are installed.
- d. The whole bow is usually constructed at a subassembly bay and placed in position rather late in the building schedule.
- e. The last step in the pre-launch construction is to paint the outside of the ship.

4. Launching--four different ways

- a. Drydock-launch--Drydock is flooded to outside water level and ship is floated out.
- b. Side-launch--Ship slides sideways into the water on ways.
- c. End-launch--Ship slides into water stern first on ways.
- d. Float-off-launch--A pontoon that can be ballasted to make it sink and flat surrounds the ship. It is made to float lifting the ship off its support. The pontoon and ship are towed out to deep water and the pontoon is filled so it sinks and leaves the ship afloat.

5. Fitting out--may take as long as a year

- a. After launching the ship is towed to a fitting out pier
- b. Large cranes move equipment into the ship such as:
 - (1) heavy machinery
 - (2) superstructure and masts
 - (3) booms and cargo handling equipment

- c. Living compartments and other spaces are painted and fitted with furniture and other equipment
- 6. Trials ("shakedown cruise")
 - a. Sound surveys
 - b. Electromagnetic radiation surveys
 - c. Antenna pattern surveys
 - d. Radar calibration
 - e. Seaworthiness test
 - f. Speed test
 - g. Endurance test
 - h. Maneuverability test
- 7. If ship passes all tests, it is considered "ready for sea".

(NOTE: Today it takes over 4,000 people about 3 1/2 years to build an aircraft carrier which contains thousands of tons of steel, hundreds of thousands of gallons of paint, and millions of feet of electrical cable.)

Types of Cargo Ships

Cargo vessels are discussed under two classifications based on the type of cargo carried--dry or liquid. In this information sheet, we are dealing with cargo vessels of the most common designs, principally the standard designs of the former U.S. Maritime Commission, and with several of the new replacement program designs of the Maritime Administration.

The principal types of dry cargo vessels are the C-types, the Victory, the Mariner, and new ships being built by American steamship companies on the "build and replace basis".

TM #10 shows the classification systems of ships according to type and length, power, propellers, and passengers.

TM #11 shows the classification such as tonnage, beam, horsepower, and speed.

The pictures that follow show various types of cargo ships.

MAIN DECK

On deck or on the main deck	CD
Shelter deck	SD
On the hatch cover or square of the hatch	ON/H
Port side abreast	P/AB
Port side forward	PS/F
Port side aft	PS/A
Starboard side abreast	S/AB
Starboard side forward	SS/F
Starboard side aft	SS/A

'TWEEN DECK AND HOLD

Orlop deck	OR/D
'Tween deck	TD
Upper 'tween deck	U/TD
Lower 'tween deck	L/TD
Top Stowage	TOP
Lower hold	L/H
False deck—lower hold	F/D
Deep tank No. 1	1/DT
Deep tank No. 2	2/DT
Deep tank No. 3	3/DT
Upper trunk	U/TR
Lower trunk	L/TR
Midship forward	MS/F
Midship aft	MS/A
All over the hatch or hold	A/O
Square of the hatch	SQ/H
Forward across the hatch P-M/S-STB	F/AC
Aft across the hatch P-M/S-STB	A/AC
Forward end of the hatch	FW/E
After end of the hatch	AF/E
Forward bulkhead in hatch	FW/B
After bulkhead in hatch	AF/B
Forward toward the bow	FWD
Aft toward the bow	AFT
Wings	WGS
Wings abreast	WGS/AB
Port wing	P/WG
Port wing forward	PWG/F
Port wing aft	PWG/A
Port wing abreast	PWG/AB
Starboard wing forward	SWG/F
Starboard wing aft	SWG/A
Starboard wing abreast	SWG/AB

MISCELLANEOUS

Chill room	CH/RM
Freezer	FRZER
Locker	LCKER
Reefer	RFER

DECKS AND HOLDS

Decks and holds are defined as follows

1. Deck.—A platform forming parts of the ship's girders, covering or extending horizontally across a vessel.

2. Main deck.—The top continuous strong deck to which all transverse bulkheads and main frames are carried, and for which there is a permanent means of obtaining watertightness.

3. Tank top.—The top side of the tank section or a double bottom.

4. Hold.—A general name for spaces below deck designated for stowage of cargo. More particularly, those spaces between the lowest deck and the bottom of the ship or tank top if there is a double bottom.

5. 'Tween deck.—Any deck in the hold of a ship between the tank tops and the main deck.

6. Orlop deck.—The lowermost deck on a ship having four decks or a partial deck below the lower deck.

7. Deep tanks.—Hold compartments strengthened to carry liquid cargo, water, ballast, and sometimes dry cargo.

8. Bridge deck.—A partial deck above the main deck usually extending from port to starboard amidships.

9. Shelter deck.—The first deck above the main deck. Not always continuous. Not permanently watertight.

10. Well deck.—The open deck running between forecastle and bridgehouse in a vessel having a raised forecastle.

CARGO HANDLING EQUIPMENT

Cargo loaded aboard ship is handled by either ship's gear or independently operated

equipment. The latter, which will not be discussed herein, includes shoreside cranes and stifflegs, or floating cranes used on the off-shore side of the ship.

BOOMS AND RIGGING

Commonly used shipboard cargo gear consists of booms supported by a mast or by kingposts. Lift capacity varies, but in modern ships 5- or 10-ton booms, or possibly a combination of the two, normally are installed. For commercial operation, 5-ton boom capacity may suffice for a particular trade, whereas for military cargo involving vehicles, 10-ton capacity booms are the minimum acceptable. In addition to the boom capacity essential for handling normal cargo, heavy-lift or jumbo booms varying in capacity from 30 to 60 tons or more usually are provided for heavy lifts; for military operations two 60-ton jumbo booms are the normal requirement. In cargo ships with the engineroom and deckhouse amidships, one heavy-lift boom is placed forward of the house and one aft. In ships with other arrangements of engineroom and deckhouse, the heavy lifts are positioned to suit.

Cargo booms usually are arranged in pairs; that is, two booms or the pair are fitted at one or both ends of a hatch. Each boom is placed port and starboard off the centerline

of the ship approximately in line with the outboard side girder of the hatch. With this arrangement, a pair of cargo booms provides considerable flexibility and can be adapted to the handling requirements of various commodities. While there are many variations in the use of cargo booms, there are three basic systems: (1) single swinging boom, (2) burtoning with conventional vangs, and (3) burtoning with coaxial vangs.

Single Swinging Boom

The single swinging boom consists of a 5- or 10-ton (or more, such as the number 4 boom on the *Marine Fiddler*, tested at 160 tons) lift capacity boom with powered topping winches, most of which are capable of lowering or raising the fully loaded boom. The boom can be swung in a horizontal plane by the vangs, one of which is positioned on each bulwark. A number of fittings, or padeyes, on each bulwark or deck provide the attachments for various positions of the vangs most suitable for an inboard or outboard swing of the boom. The swinging boom is moved to a position directly over the cargo ashore, and the hoisting winch lowers the hook for attachment of the cargo. The loaded hook is then raised far enough by the purchase to clear the ship's bulwark or railing. The boom is swung inboard by the vang opposite the shoreside to place the cargo in the square of the hatch or on deck as the case may be. The operation is performed in reverse when discharging cargo.

WT 3.15

Information Sheet #4

Swinging booms are advocated by insurance carriers as a safety feature when the weight exceeds the safe burtoning load.

Burtoning With Conventional Vangs

The burtoning system with conventional vangs is utilized most commonly for loading and discharging medium weight cargo (1 to 1 1/2 tons). The rig also is known as the "union system," "married falls," and "yard and stay."

The system consists of two booms, each held in place by two vangs or by one vang and a schooner or lazy guy run between the two boom heads. In the latter arrangement, the hauling part of the schooner guy is run down the side of the booms to a cleat near the heel of the booms. This arrangement requires only one vang for each boom in addition to the schooner guy; it is preferable to the system

requiring two vangs for each boom. Either arrangement utilizes two winches for hoisting.

The working position of this system would have one boom topped over the hatch, and the other over the pier-side with the booms held in position by the vangs and schooner guy. In a loading operation the cargo runner on the pier-side boom raises the loaded hook vertically to a height sufficient to clear the ship's bulwark or other obstruction. In some instances the cargo runner is led through a block on the housefall structure on the pier instead of using the pier boom. Then the hatch cargo runner starts pulling the hook inboard towards the boom over the hatch while the pier boom runner pays out until the loaded hook reaches its position over the hatch. After the load is lowered into the hold, the hook is released and the hoisting winches reeve in the runners so that the hook travels vertically above the hold, then athwartship, and finally vertically down to the pier for a new load.

The transfer of cargo between the hold and the pier is performed by using the two winches in one continuous operation while the load remains in suspension throughout the operation.

Burtoning With Coaxial Vangs

Burtoning with coaxial vangs is identical in operation to burtoning with conventional vangs except that the outboard vangs, one for each boom, lead through a swivel attachment of the vang sheaves located on the horizontal axis passing through the heel pins of the booms. The boom heads are connected by a schooner guy. The coaxial feature permits topping of the boom heads without adjustment of the vangs and therefore provides a cargo spotting ability in a fore-and-aft vertical plane which is of considerable value. Transverse movement of the booms is made by adjustment of the vangs similar to burtoning with conventional vangs.

Rigging Tackle

Pulleys and ropes can be used in combination to provide mechanical lifting advantage in moving cargo on and off a ship. If you live on a farm, you may have a wire stretcher which is like the rigging in TM #15. TM #18 (A,B,C) show the 6 mechanical advantages (MA) of different ways of rigging tackle.

SPANISH BURTONS

Occasionally it is necessary to hoist a load that exceeds the capacity of any tackle at hand. Of course, you could rig two tackles that together would be strong enough to accomplish the work. However, if you also were short of power, you would gain a power advantage by rigging a Spanish burton, or continuous fall.

It may be difficult to understand how such a rig gives a power advantage over two tackles, therefore, let us consider the situation

In view A, it is obvious that with the mechanical advantage (MA) of two, 250 pounds pull on each of the hauling parts will lift the two 500-pound weights. (Throughout this discussion we will disregard friction.) It also is easy to see that if the two 500-pound weights were replaced by one of 1000 pounds that the two 250-pound forces still would lift the load.

Now consider view B. For the sake of this discussion let us say that the line is secured at the center fairlead block (F) instead of being rove through it. We would then have two whips and runners with MAs of two, and still need 250 pounds of force on each hauling part.

Reeving the line through the fairlead block does not alter the MAs. We still need the two 250-pound forces.

What happens, however, if we secure one hauling part? (View C) Do we now need a 500-pound

force on the other in order to hoist the load? Not at all. You can see by inspection that the MA now is four. Hence, we only need 250 pounds of force to do the same amount of work.

SLINGS--When hoisting cargo a net or pallet sling of the correct size should be used. (TM #23)

Variations

When a hatch is double-ganged (two sets of booms and winches installed), one set (or pair) of booms can be used to hoist stores from the hold to the transfer area topside, and one or both booms of the other set are employed for burtoning to either or both sides simultaneously.

If there is only a single set of booms per hatch and one winch per boom, the boom on the engaged side is rigged for burtoning, and the other is rigged for hoisting cargo from the hold. The hatch boom is spotted so that its whip plumbs the center of the hatch, and a lizard is shackled to the whip. Cargo is picked up by the whip and spotted on deck by means of the lizard.

The double-ganged hatch and double-rigged booms provide the greatest speed and efficiency in handling the transfer of solids or packaged goods.

There also are various ways of doubling up burton whips to handle loads up to 12,000 pounds when certain conditions specified in NWP 38 are met. The basic doubled-whip burton rig is shown

Acceptable and unacceptable modifications are shown

The rigs in the two bottom views will carry the load but are unacceptable because neither ship has a payout or recovery rate for maintaining the proper catenary and allowing for rapid movement between ships.

HOUSEFALL METHODS

Housefall methods of transferring differ from burton methods in that all sources of power are located on the delivery ship. Like burton methods, however, rigging can be done in several ways.

One of the most efficient rigs requires four winches and uses the boom and kingpost on the engaged side for the housefall. The boom on the unengaged side is used in conjunction with the outside boom in a yard and stay rig for hoisting cargo from the hold.

CRANES

Considerable effort has been made to promote revolving type shipboard cranes as a substitute or adjunct to the commonly used boom and mast or kingpost. There can be no doubt but that cranes in one form or another may be advantageous for handling some commodities and for use on certain configurations of ships.

However, to consider this system of cargo handling as a complete substitute for the

normally used gear on conventional ships, does not appear to be warranted at the present time; first, because cranes are very costly, and second, it is difficult to increase their load-carrying ability once it is established in the design.

Opinions differ as to the value of cranes for shipboard use. Many operators prefer the boom, which, within limits, can readily be replaced or rerigged for greater load capacity or increased reach. Whether a crane can handle the cargo faster than burtoning gear

has not been established, if one considers miscellaneous cargo.

Revolving type cranes have been fitted on a number of foreign ships and in one American commercial cargo ship built for the Mississippi Shipping Company, in New Orleans, Louisiana. This ship is unique with respect to its cargo handling features. The forward hold is served by two 5-ton capacity conventional booms; the remaining five holds (each 50 feet in length) are subdivided athwartship into three spaces each, with each space served by a hatch. Five revolving cranes of 5-ton lift capacity are arranged to work the 15 hatches. In addition there is a single jumbo boom of 30-ton lift capacity located amidships; it is of the Stulken type; that is, the single boom can serve the hatch forward of the gear as well as the hatch immediately aft. There are other examples of smaller type American ships that have found cranes to be profitable for a particular commodity such as packaged lumber or provisions. One is a lumber carrier, operated by W.R. Chamberlin on the west coast, fitted with two 10-ton cranes; another is the Army Transportation Corps self-propelled barge fitted with two 5-ton cranes for handling supplies and provision type cargo.

SPECIAL GEAR

In addition to the ship's cargo-handling gear, longshoremen use various pieces of equipment to facilitate and speed cargo handling and lessen the physical labor involved. Gravity and mechanical conveyors, forklift trucks, cargo chutes, hand dollies and trucks, drag lines and rollers, cargo pallets, and nets are typical appliances utilized by stevedores.

An example of other special gear is the sideporter, which basically is a crane or trolley supported on overhead runners mechanically extended through a side port. This device is employed mostly on passenger ships for stores, baggage, and similar items, and seldom is found on regular cargo ships.

For the handling of grain, mechanical suction tubes using the vacuum cleaner principle and the reverse process, load and discharge this cargo very effectively. Another rather special mechanical device, used for loading coal and sometimes ore, lifts a fully loaded railroad car and dumps the contents into the ship in one operation.

CONTAINERIZATION

Although the break bulk method of stowage (the system of loading cargo whereby items are lifted into the ship and stowed individually) is very efficient from the standpoint of shipboard space utilization, it also is very expensive. Cost estimates for loading and discharging a ship consistently exceed 50 percent of the total cost involved in transporting a shipload of cargo overseas.

The commercial shipping industry vitally interested in reducing this cost wherever possible. About 1958, some shippers started moving certain cargoes by means of containers delivered to the ship, taken aboard, and unloaded as one item of cargo. The container concept can best be visualized as the trailer section of a tractor-trailer truck, in which the fully loaded van is handled as a unit.

In recent years, a number of commercial shipping firms have seriously entered the container-cargo field to the extent that at least one company—Sea-Land Services, Inc.—is building its own container ships. Other companies such as United States Lines, Moore-McCormack, Matson, and Seatrain Lines have converted some holds or entire ships to accommodate containers or are planning to build fast all-container ships.

The Maritime Administration participated in the conversion of certain ships by adding a 45-foot midsection and widening the beam by 11 feet. This latter was accomplished by adding sponsons, by dividing the ship into cellular holds, and by installing three Pacoco gantry cranes. The ships were equipped with special hatch covers, automatic tensioning winches and a new bridge to provide unimpeded vision over the cranes. Associated with the conversion of the ships was the purchase of 1500 containers designed to fit the holds of the ships.

The containers involved are of reusable, solid-metal or wood-construction and may be used to stow almost any type of cargo. They are of no standard size, but current preference leans toward dimensions of 20 feet long by 8 feet in width and height. They are delivered to shipside packed and ready for loading. Large cranes, either on the pier (preferably) or ship, hoist them aboard and discharge them on arrival at the delivery point.

The aim of containerization is cost reduction, which in some cases is truly remarkable.

Since each container holds at least 10 tons of cargo loaded as a unit, the loading rate is in the neighborhood of 250 tons per gang-hour as compared to about 20 tons for break bulk stowage. Consequently, turn-around time involving a full load of cargo becomes perhaps 1/2 day rather than 3 or 4 days, depending on ship size. With port fees running several thousand dollars per day, the cost of loading and sailing a ship can be reduced by some \$10,000 per trip per container ship.

To keep the container ship concept in proper focus, however, one must consider disadvantages as well as advantages. A number of the important considerations can be summarized briefly as follows:

Advantages

1. More rapid turnaround.
2. Since cargo is "locked in," protection against pilferage.
3. If cargo is properly packed, greater protection against damage.
4. Lower insurance rates.
5. Less expensive packaging of commodities (domestic rather than export wrapping).
6. Reduction of multiple product-handling.

Disadvantages

1. Cost of containers.
2. Amortization of containers. If the life expectancy of a container is 5 years, for example, this could be a very expensive proposition considering that the initial cost of a container is several thousand dollars.
3. Accountability of containers.
4. Cost of returning empty containers. Container operations can be competitive only when there is a substantial flow of containerable cargo in both directions.
5. Foreign travel restrictions at pickup point (narrow roads, small tunnels, et cetera).
6. Shipboard cell construction and special hatches/hatch covers required.
7. Enlarged clearance facilities needed ashore.
8. Varying freight rates on packaged commodities.
9. Loss of cubage in containers.

WT 3.20 CARGO STOWAGE

Physically stowing cargo in a ship is the most important of the loading operations. Skill in manufacture of material, care in shipment to the terminal, and safe and careful handling are of no avail if, on the final stage of the movement, the materials have been improperly stowed. Damaged cargo is of no value either to a commercial consignee in peacetime or to the military in wartime. In the first case,

money is lost. In the second case, human lives may be lost if needed equipment is not received in usable condition, where and when needed.

The importance of proper stowage cannot be emphasized too strongly. Improper stowage can cause the cargo to shift and may force the ship to return to port. Fire may break out with disastrous results. In many cases improper stowage has caused so much damage to portions of a cargo as to render it worthless. Particularly from the military standpoint, proper stowage is vital.

A few of perhaps hundreds of problems in stowing a ship are:

1. Cargo must be available on time.
2. Size of hatches, dimensions of holds, capacities of booms must all be carefully considered.
3. Items must be stowed so that they will not damage one another, spoil, burn, or deteriorate.
4. Stresses and strains on decks and beams must be taken into account.
5. Crew must not be subjected to danger.
6. Ship should be properly trimmed.
7. Weight must be distributed among the various holds to reduce hogging or sagging.
8. Cargo may be loaded and/or unloaded at a number of ports. Yet the cargo to be unloaded at a given port must always be readily available at that port. After unloading, the ship must still have an acceptable trim and the cargo weight must be distributed vertically and horizontally in a satisfactory manner.

The characteristics of the ship are a major consideration in cargo stowage. The shape of the ship is important. Sheer, flare, and pointed ends, all determine what cargo can be stowed where. Obstructions in the holds such as bilge brackets, stanchions, piping, and shaft alleys are all factors to be considered. For deck loads, the considerations are weight in relation to weight in the holds, permissible concentration of weight, available deck space, and obstructions.

Because holds and other cargo spaces are not of uniform configuration throughout a ship, stowing cargo in the forward and after spaces where the contour of the hull changes rapidly, presents a more difficult problem. Stowing cargo in the midship portion utilizes available space more efficiently. For this reason some cargo ships are arranged with the propulsion machinery aft rather than amidships, thereby

assuring a greater volume of uniform cargo space and improved stowage. A study made to compare the effect on cargo bale cubic with machinery amidships or aft, showed a 10 to 15 percent gain in the latter case.

Nevertheless, commercial operators have not favored this arrangement in preference to placing the machinery amidships. Some contend that machinery aft makes it difficult to keep the ship in proper trim, and adversely affects the ship's behavior in heavy seas. It is also claimed that if the pilothouse and bridge are aft, the view forward is seriously obstructed by rigging and cargo gear.

Principles of Stowage

There are four fundamental principles of good cargo stowage:

1. The ship should be "full and down"; that is, full of cargo and down to her Plimsoll mark.
2. Stowage must protect the ship and crew from injury.
3. Stowage must protect the cargo.
4. Stowage must be such as to facilitate speedy discharge.

THE PLIMSOLL MARK.—"Full" refers to filling the vessel's underdeck cubic carrying capacity. Cargo on deck is not included and allowance is made for expected broken stowage. "Down" refers to the weight of the cargo bringing the draft to the ship's deepest permissible draft. Therefore, "full and down" expresses the maximum utilization of the ship's cargo capacity.

Naval and commercial ships are assigned a limiting draft marked on the hull. This mark is often called the "Plimsoll" after Samuel Plimsoll, a member of the British parliament, whose efforts from 1868 to 1880 resulted in the passage of laws regulating the limiting draft of British commercial ships. The basis for draft assignment, whether it be applicable to a naval or commercial ship, involves the structural strength, stability, reserve buoyancy, and characteristics related to the particular service intended for the ship.

The limiting draft of naval combatant auxiliary ships is determined and controlled by the Navy Department. The draft mark is indicated by the upper edge of a horizontal bar 18 inches long and 1 inch deep. At the middle of the bar a capital V is placed on the upper

edge and an inverted V in the same position on the lower edge. This marking is placed on both sides of the hull, by painting, welding or chipping, on some ships at the bow and stern, on others amidships or in a combination of these positions.

Oceangoing commercial ships certificated by the U.S. Coast Guard and the American Bureau of Shipping are regulated by the requirements set up by the International Load Line Convention and Acts of Congress. The American Bureau of Shipping assigns the load line for American ships that are registered both in the United States and in other countries. MSTs also meets these standards. For both cargo and passenger vessels the draft or plimsoll mark consists of a 12-inch diameter circle or disc crossed by a horizontal bar 18 inches long. The upper edge of this bar passes through the center of the disc and represents the limiting summer draft. The disc is placed on both sides of the vessel and centered at the middle of the length of the load line. The disc and lines must be permanently marked by center-punch or chisel. In addition, other supplementary markings are placed 21 inches forward of the disc to indicate allowable draft in fresh water, tropical zones, winter, and winter in the North Atlantic.

PROTECTION OF SHIP AND CREW.—The second principle of good stowage is protection of ship and crew. The stowage of cargo in a manner that will not endanger the ship or its crew means that the cargo should be distributed so as to insure the stability of the ship; it must be secured against shifting or a break-away. Cargo also must be distributed in such a manner that the ship will be neither too tender nor too stiff. The stability can be varied by placing heavy cargo (cargo with a low stowage factor) either higher or lower in the ship to make her more or less tender, i.e., to change the characteristics of her roll.

Other factors which protect ship and crew are list, trim, fire prevention, and ventilation. Obviously cargo must be so stowed that the ship will not list and the cargo must be so secured that heavy seas will not shift it and cause a list while the vessel is at sea. Trim is usually a matter for the individual captain to decide. Some prefer an even trim, but the majority prefer a drag (with the stern lower in the water than the bow). Fire prevention is of the greatest importance. Cargo

must be stowed so that a fire could be properly controlled. Dangerous articles require special consideration.

PROTECTION OF CARGO.—The third principle of good stowage is protection of cargo. There is little point in shipping cargo unless it will arrive at its destination in good condition; it must be carefully and compactly stowed. Because rolling and pitching of a ship can place tremendous strain on cargo, the cargo must be properly dunnaged and shored to prevent its breaking and shifting.

Cargo must be properly located in the various holds. This is largely a matter of common sense. Bags of cement should not be stowed with bags of grain. Heavy steel beams should not be stowed on top of lightly crated airplane parts. Dangerous cargo such as acid, bomb detonators, or gasoline should not be stowed in a hold with general cargo. Each should have special stowage. The Code of Federal Regulations (Title 46--Shipping; parts 146 to 149) spells out the restrictions on stowage of hazardous materials.

Some types of cargo need adequate ventilation to prevent spoilage. Wheat, green lumber, hides, and many other items will themselves deteriorate or damage adjacent cargo because of excessive heat or lack of ventilation. A few progressive companies have installed cargo dehumidification systems in the holds of their vessels for air conditioning to prevent damage from moisture and mildew or excessive heat.

Special precautions must be taken in stowing some types of cargo to prevent spontaneous ignition. Hay and wool fall into this category. The dangers from a fire of this type originating far down in a hold filled with cargo are obvious.

Fruit, meat, and many other commodities require refrigeration. For this type of cargo a refrigerated ship or reefer is used. Aside from the straight reefer or all-refrigerated ship, some ships are built with one or more refrigerated holds. This provides a much greater flexibility in the types of cargo that can be carried.

Special precautions should be taken in stowing vehicles and other rolling stock within the hold or on the weather deck and in securing them after the vehicle has been spotted in the assigned space. Heavy trucks and trailers can kill a man if they break loose; vehicles must be chocked, braced, and securely lashed in place with wire or chains.

Airplanes are another special item. Stowage procedures were worked out at NAS San Diego in World War II for ocean shipment of planes aboard oilers, cargo vessels, seatrains, or escort carriers. Planes were first preserved, a "spot" (loading plan) was worked out, and the planes were loaded aboard and spotted in place. The wheels were chocked and the chocks were secured to the deck. Braces were fitted under the wheels so that a flat tire would not allow a plane to settle slowly onto another, with a corresponding crunching of wing tips. Battens were placed over ailerons, rudder, and elevators. The plane was then securely wired to the deck using come-a-longs and wire clamps. This rather complicated procedure was, of course, not necessary under all conditions. However, its value has been attested to by the low number of casualties to planes so stowed.

SPEEDY DISCHARGE.—The last principle of good stowage is that of speedy discharge. The larger the number of ports involved, the greater the problem. Cargo may be loaded at various ports, removed at several other ports, yet the ship must retain proper trim and stability. At the same time, cargo for the next port must be readily available for unloading at the proper time.

In addition to the careful planning obviously required, great care must be taken in the actual stowage of cargo to ensure that plans are carried out and stowage diagrams and manifests are correct. Also when cargo is destined for a number of ports, markings become most important. Assuming a ship loads cargo at each of three ports for discharge at each of three or four other ports, the complications are obvious. In the Navy, stowage is further complicated since much cargo is assigned priorities of unloading and by the fact that cargo for a number of destinations usually must be segregated.

Broken Stowage

When stowing cargo it is impossible to utilize 100 percent of the space in the holds and 'tween decks, except where the cargo is liquid or grain. For boxed cargo, drums, building materials, vehicles or general types of cargo, a certain part of the available space cannot be completely

filled. This loss of space is referred to as broken stowage and varies throughout the ship and with the type of cargo. On commercial cargo ships the average broken stowage is in the range from 15 to 25 percent of the total bale cubic in terms of general cargo. For MSTs ships, 25 percent broken stowage is usually assumed for general cargo, but it reaches about 50 percent or more on roll-on/roll-off ships.

Assume that a hold measures 6000 cubic feet. Cargo measures 5000 cubic feet according to the booking. When stowed in the hold the cargo occupies all the 6000 feet of hold space. The broken stowage, therefore, would be 1000 cubic feet. The percentage would be 1000 divided by 6000 or 16.7 percent. From long experience in stowage, average broken stowage figures have been arrived at for nearly all commodities.

It is interesting to note that the use of a broken stowage figure in planning can conceivably result in a vessel taking more cargo than there is space in her holds. If the actual broken stowage is not so great as the amount on which the planning was based, it is obvious that more cargo will go in than the ship would appear to hold. Another case of this is the truck and the jeep. In loading the ship, the planner figures that a jeep will occupy a certain number of cubic feet. The truck also will be listed as a certain number of cubic feet. Now, if in actually loading a cargo of trucks and jeeps of 50,000 feet total cube, the jeeps are put inside the truck—a booked 50,000 cubic feet of cargo might go into 40,000 cubic feet of space.

On-Deck Cargo

On-deck cube is not included in the cubic capacity calculations for full. On the other hand, on-deck cargo tonnage is included in the down figure. In other words, as more on-deck tonnage is utilized the underdeck tonnage capacity is decreased. However, underdeck cubic capacity remains constant, so the stowage factor of underdeck cargo to get full and down increases. In actual practice several hundred tons of cargo are usually held out until the ship is nearly loaded, and are then used for trimming.

CARGO HOLDS

Cargo holds vary in size and shape, depending on the ship and their locations aboard ship

are typical of forward and after holds with beam and board covers. The numerical key to both illustrations is as follows:

- | | |
|------------------------|--------------------|
| 1. Removable beam | 10. Sweat batten |
| 2. Cargo hatch coaming | 11. Tank top |
| 3. Twen deck | 12. Beam socket |
| 4. Hatch ladder | 13. Lower hold |
| 5. Bulkhead | 14. Stiffener |
| 6. Stanchion | 15. Ceiling planks |
| 7. Ring | 16. Shaft alley |
| 8. Flare | 17. Skin |
| 9. Frame | 18. Hatchboards |

New replenishment ships have an entirely different arrangement. The lofty holds and large open hatches are gone. A typical hold is as deep as the space between decks. It has a small hatch at one or both ends, served by an elevator operating in a trunk. In the hold fork lift trucks bring cargo to the main deck.

Cruise Liners

Cruise liners are large passenger ships. Ships like these are used for vacations and not for trans-ocean travel because jets are faster and less expensive.

There are many cruise ships in the United States. Most are located in Miami for trips to the Carribbean area. There are also ships on the West Coast that travel between Washington state and Alaska.

Each ship has many cabins (rooms) for people to sleep in while on the ships. These ships also have pools, restaurants, athletics, and many other activities.

Many people and many types of work are needed to design, build, and operate these ships.

WT 3.25

NAVIGATION



Navigation

To people who go to sea, either off shore or on soundings, there is no skill more basic or more important than finding the position of the vessel. The ancient art of navigation has not been superseded in the Atomic Age.

Today, there is the natural danger that new, exciting areas of knowledge, such as missilery and nuclear propulsion, will claim an undue share of attention--significant as they are--to the detriment of the older sciences. Navigation has its own share of the new and the exciting. Yet the book also underlines the fact that neither the sextant nor common sense has been replaced by any black box.

In every man-of-war, in every commercial or pleasure vessel, there must still be a person--the Navigator--who takes exceptional pains with the work, who seeks and uses every possible scrap of information to check the work, and who scrupulously avoids making an assumption unsupported by facts. Anything less than the utmost devotion to duty by the Navigator means the vessel will be unsafe and her mission be left undone.

FINDING YOUR POSITION AT SEA USING THE CELESTIAL BODIES

"Shooting the sun" is often somewhat of a mystery to today's navigator, particularly if he has ever attempted to thumb through Dutton's. It seems that the subject can only be understood by a mathematician or an astronomer and the text tends to discourage further study.

Just as other sciences have become "modernized", celestial navigation has been developed to the extent that the present day navigator conducts his work more like an accountant than a mathematician. Modern methods and tables have reduced the task to one of adding and subtracting numbers. The mysteries of logarithms, astronomy, etc. have been already solved and presented simply in present day tables.

This formerly complex subject has been mastered by those with little or no background in mathematics, so that even housewives can be found using the sextant today.

The principles of modern day celestial navigation are simple enough to understand, and can be illustrated with the aid of a few pictures. All that is required, in addition, is some study of the use of well prepared tables and the techniques of plotting.

We are able to find out position at sea because astronomers can predict accurately the location of the celestial bodies relative to the Earth. Each of these bodies has a "GP" or Geographic Position on the surface of the earth. This "GP" can be viewed as the point where an imaginary line connecting the Earth's center to the body, intersects the earth's surface. If anyone was standing at the GP, he would observe the body to be situated exactly overhead as in Figure #1.

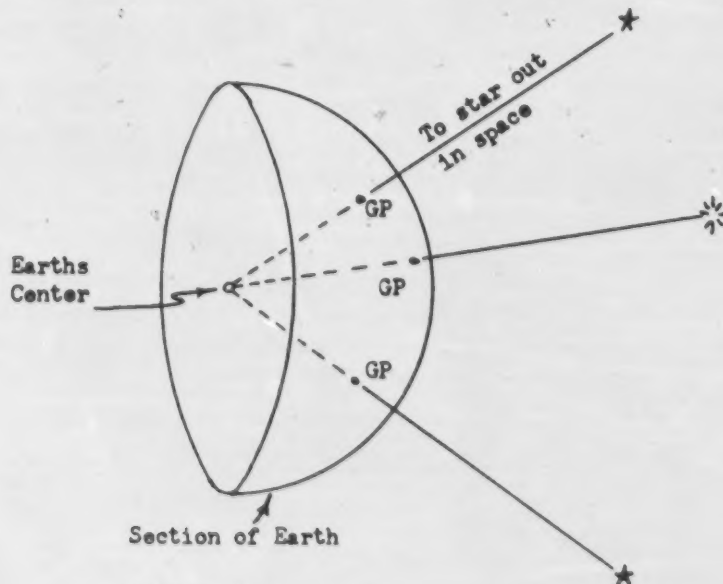


Figure #1

DOPPLER NAVIGATION

If a sound beam is transmitted from a moving ship, when this sound beam strikes the bottom, some of the sound will be reflected back to the ship in the form of an echo. This echo will have a slightly different sound frequency between the transmitted sound and the returning sound because of the ship's motion. The idea can be better visualized in the situation of a moving train. Imagine yourself standing at a train station with an approaching train sounding its whistle. As the train approaches the sound of the whistle begins to sound differently and the pitch varies until the train passes.

The difference in frequency between the transmitted sound and the returning echo is proportional to the speed the ship is traveling in the direction of the sound beam. If this sound beam is directed ahead or astern, the speed of the ship can be determined.

When two such beams are used with a fixed angle between them and the two rotated about a vertical axis until both frequency readings are the same, direction of motion can also be measured. In this case the measured speed is a fixed proportion of the actual speed.

A computer can integrate both the speed information and direction of motion information with elapsed time and thus give us precise position data.

The Doppler Method may be used in conjunction with inertial navigation to provide accurate position information. The two systems combined are capable of providing accurate positions over short distances, but since errors are cumulative they cannot be considered as anything more than an excellent aid to the navigator.

This Doppler System is being put to practical use by Maritime Shipping companies, in that some of the large supertankers are beginning to use the doppler method to help dock these large ships.

The "black box" shows the conning officer on the bridge how the far off bow is moving until the ship is docked or anchored.

The problem in berthing a ship with a deadweight tonnage of 200,000 or more can be reduced considerably if the conning officer can tell what direction the ship is moving when its speed is less than one knot. A ship this large approaching a jetty at a speed of about a quarter knot (25 ft per minute) could cause damage, but if she nestles up to it at only 15 feet per minute, the jetty should be perfectly safe and the ship's cargo can be delivered on time.

Other Navigation Aids

There are other types of navigation aids using satellites, inertial guidance systems, gyroscopes, shore based transmitters, and computers and other electronic services that help the navigator locate the ship very accurately at sea. These location devices are used with charts (maps) of the oceans so ships can tell exactly where they are located.

Canals

Two of the most famous canals in the world are the Panama Canal and the Suez Canal. They both have been, and still are, very important to ocean transportation. You studied about them in Geography.

The Panama Canal is a locko-type canal (like those on our inland waterways). It crosses the country of Panama and connects the Atlantic Ocean to the Pacific Ocean. The country of Panama is in Central America. The Panama Canal is 51 miles long and the highest point is 85 feet above the oceans. Ships up to 1000 feet long and 110 feet wide can go through the locks.

It took a long time to build the canal and the story is very interesting. Look up the Panama Canal in the encyclopedia in your school library and read about it.

A trip through the Panama Canal saves having to go all the way around South America.

The Suez Canal is one of the most important waterways in the world. It goes from the Mediterranean Sea to the Gulf of Suez between Egypt and the Sinai Peninsula. It is 104 1/2 miles long, about 500 feet wide, and 37 feet deep.

The Suez Canal is near the Mid-East oil fields and has an interesting history too. Read about it in your school library.

By going through the Suez Canal ships can save 5,000 miles by not having to go around Africa.

Job Opportunities

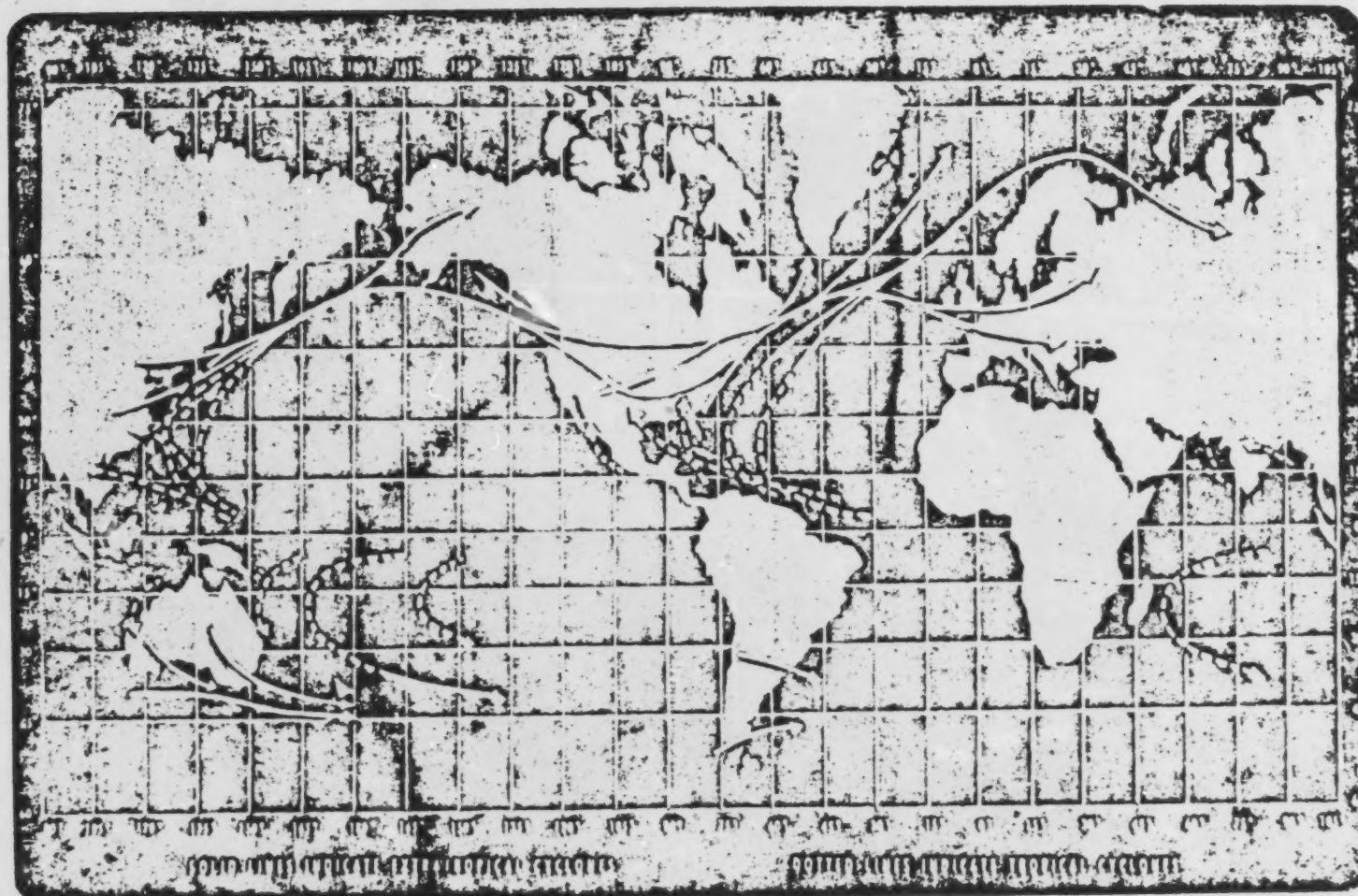
1. Dictionary of Occupational Titles (civilian jobs)
2. U.S. Navy (have a Navy recruiter talk to class)
3. U.S. Merchant Marines

MERCHANT MARINE TRAINING

The program for training personnel for service in the merchant marine was established in 1938 by the U.S. Maritime Commission. Training stations and supplementary training ships were established on the Atlantic, Gulf, and Pacific coasts. In postwar years merchant marine training became a function of the Maritime Administration, under which a peacetime training program now functions through the U.S. Merchant Marine Academy and state maritime academies.

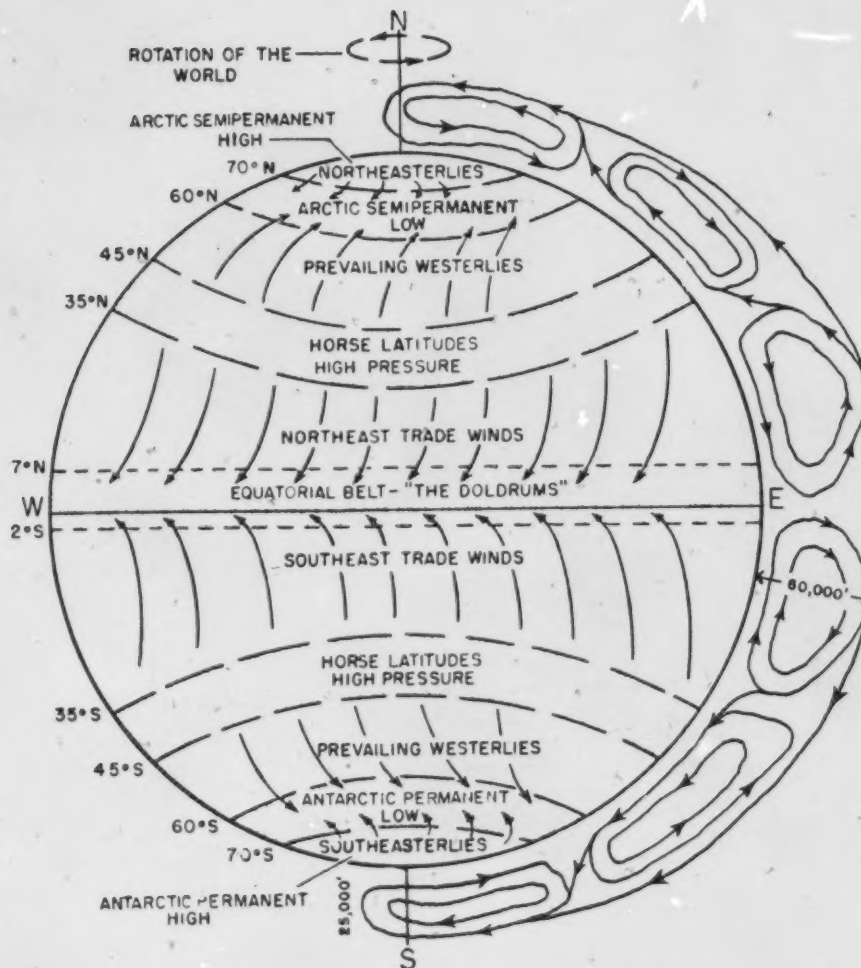
The Merchant Marine Academy trains American citizens, high school graduates and under 21 years of age, to become officers in the merchant marine. The course is 4 years: the first year at the Academy, located at King's Point, New York, the second year aboard merchant ships, and the last 2 years at the Academy. Graduates receive a merchant marine license as third mate or third assistant engineer and are eligible to apply for a commission as ensign in the Naval Reserve. The Academy grants a bachelor of science degree.

In addition to the academy at King's Point, the Maritime Administration supervises five merchant marine schools in Maine, New York, Massachusetts, California, and Texas. These state institutions operate partially with the aid of Federal funds under Federal requirements. Upon graduation, students receive a license similar to those awarded King's Point graduates and upon individual application and acceptance, a commission as ensign in the Naval Reserve.



Tropical and extra tropical storm tracks

T.M.-1 / WT 3.31-A



General circulation of air.

At times confusion arises from the meaning of wind direction. Wind is always named by the direction from which it is blowing.

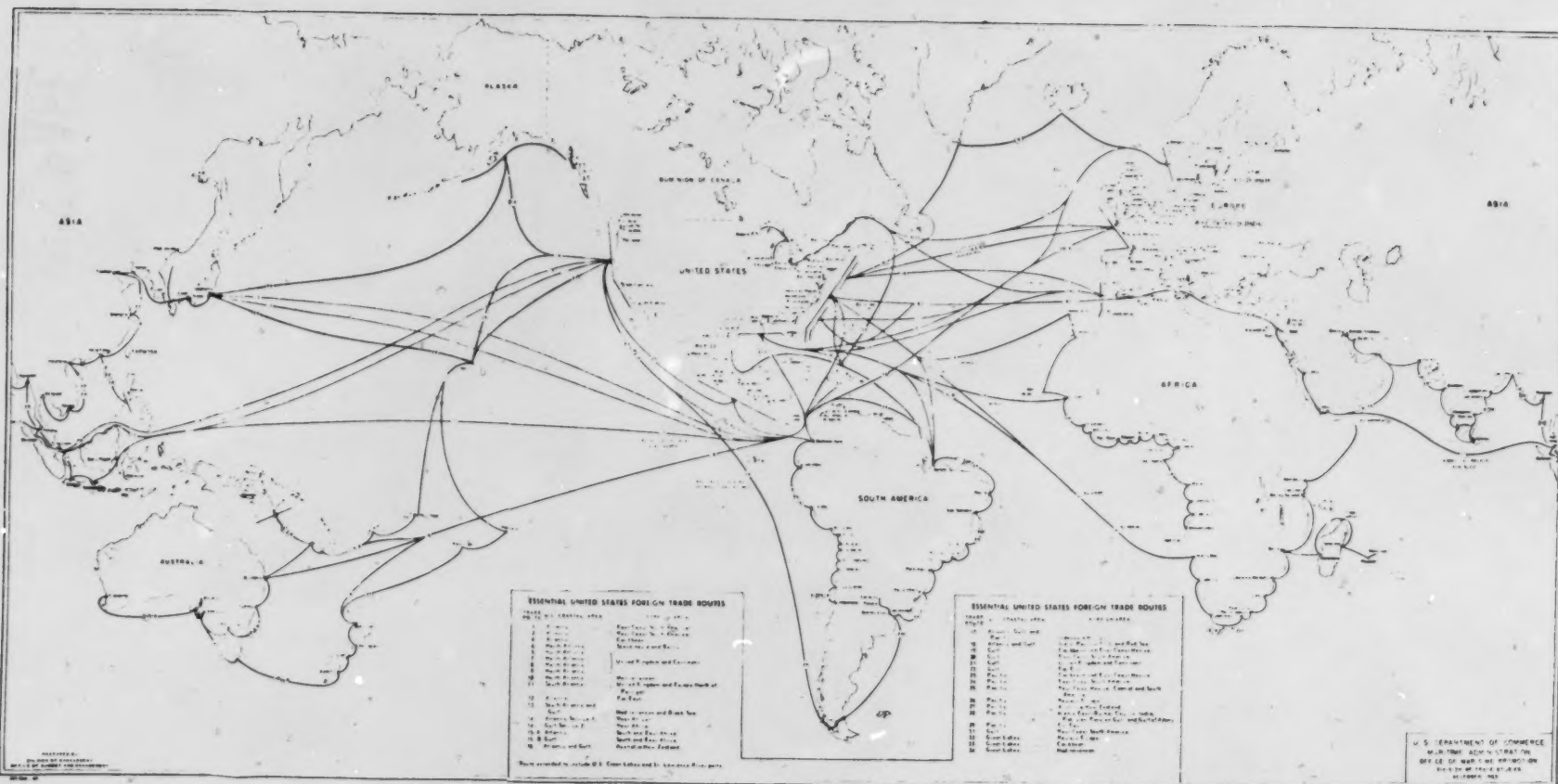


Figure 3. Essential United States foreign trade routes.

T.M.-3 / WT 3.31-C

OCEAN TRANSPORTATION

Merchant Fleets of the World, 1966¹

[DWT: Deadweight, thousands of long tons]

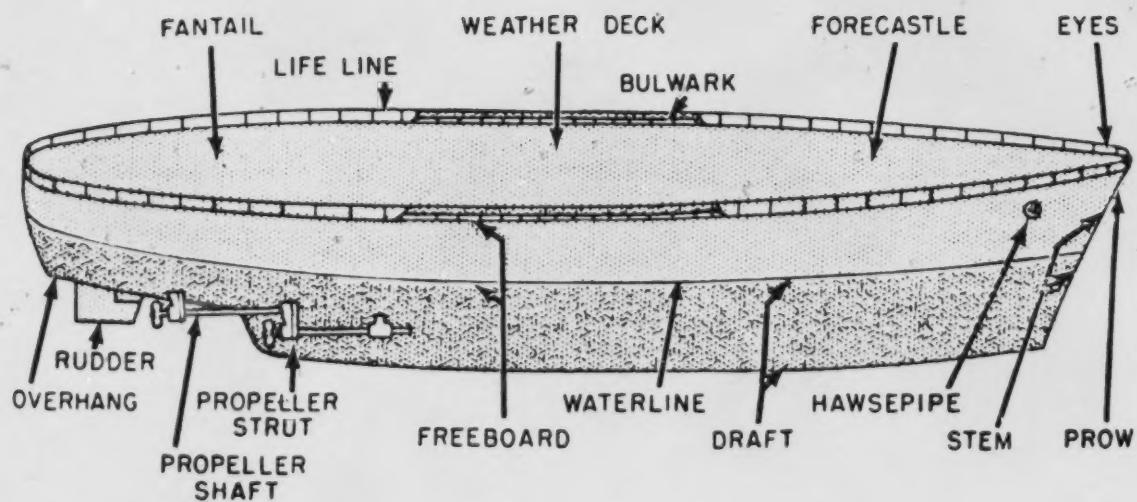
Country	Total		Combination passenger and cargo		Freighters		Bulk carriers		Tankers	
	No.	DWT	No.	DWT	No.	DWT	No.	DWT	No.	DWT
United States ²	2,292	27,392	225	1,476	1,676	17,443	63	1,122	328	7,351
Other NATO countries.....	6,889	87,063	414	2,349	4,215	32,436	839	14,508	1,421	37,770
France.....	536	6,535	42	222	282	1,781	57	709	155	3,823
Effective U.S. control.....	485	15,400	8	50	90	898	102	3,103	285	11,349
U.S.S.R.....	1,360	9,811	81	243	874	4,889	166	1,114	239	3,565
China (Communist).....	180	1,023	20	42	122	766	19	83	19	132
Other.....	6,561	75,190	290	1,140	4,315	31,480	793	13,538	1,163	29,032
Total.....	18,303	222,414	1,080	5,522	11,574	89,693	2,039	34,177	3,610	93,022
Percent of total, all flags										
United States.....	12.5	12.3	20.8	26.7	14.5	19.4	3.1	3.3	9.1	7.9
Other NATO countries.....	37.6	39.1	38.3	42.5	36.4	36.2	41.1	42.4	39.4	40.6
France.....	2.9	3.0	3.9	4.0	2.4	2.0	2.8	2.1	4.3	4.1
Effective U.S. control.....	2.7	6.9	0.7	0.9	0.8	1.0	5.0	9.1	7.9	12.2
U.S.S.R.....	7.4	4.4	7.5	4.4	7.5	5.4	8.1	3.3	6.6	3.8
China (Communist).....	1.0	0.5	1.9	0.8	1.1	0.9	1.0	0.2	0.5	0.2
Other.....	35.9	33.8	26.9	20.7	37.3	35.1	38.9	39.6	32.2	31.2
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

¹ 1,000 gross tons and over as of June 30, 1966.² Includes reserve fleet figures.

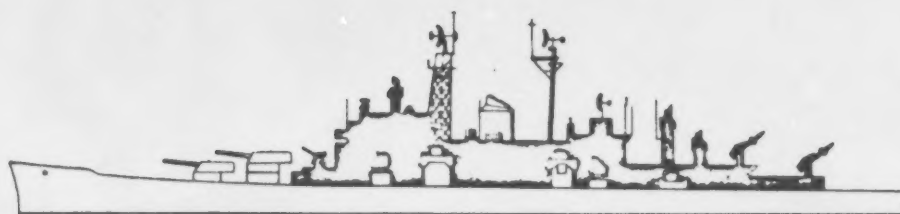
Derived from: U.S. Department of Commerce, Maritime Administration, Report No. MAR-560-20, Nov. 9, 1966.

EXTERNAL EQUIPMENT OF SHIPS

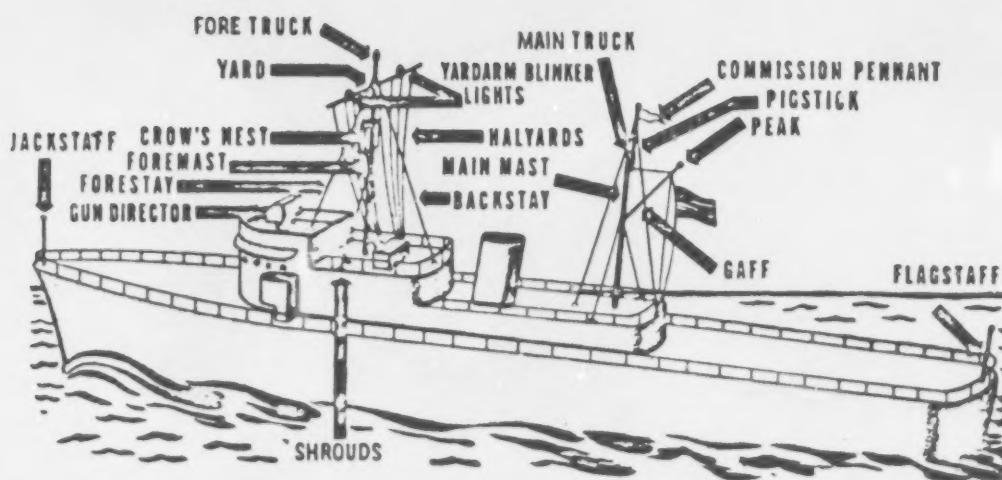
THE HULL



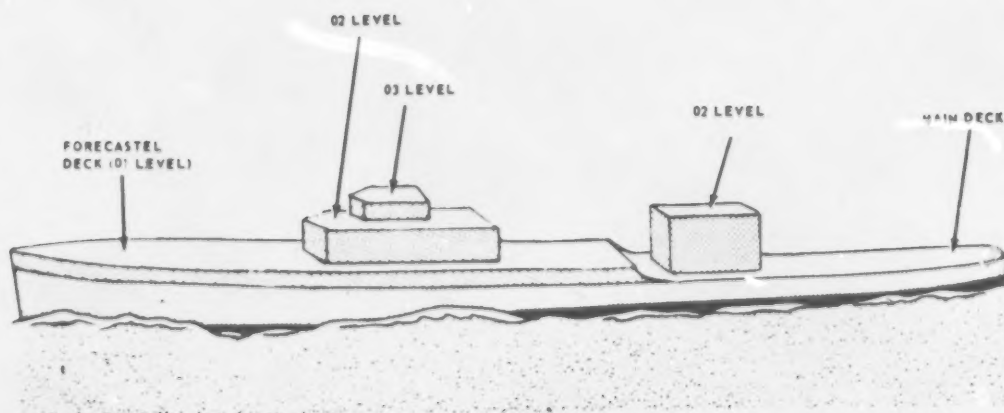
Parts of a ship's hull.



Superstructure.

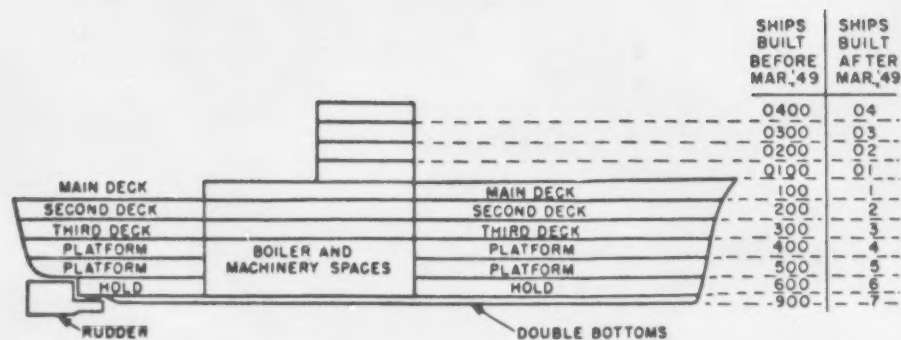


Top hamper.

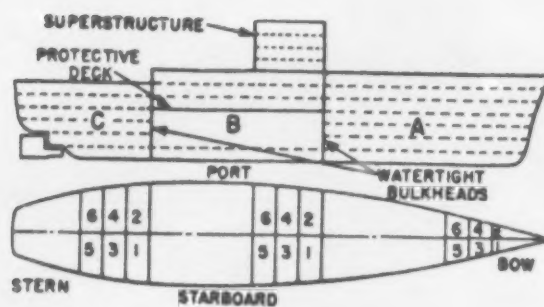


Any deck or portion of a deck that is exposed to the elements is referred to as a weather deck.

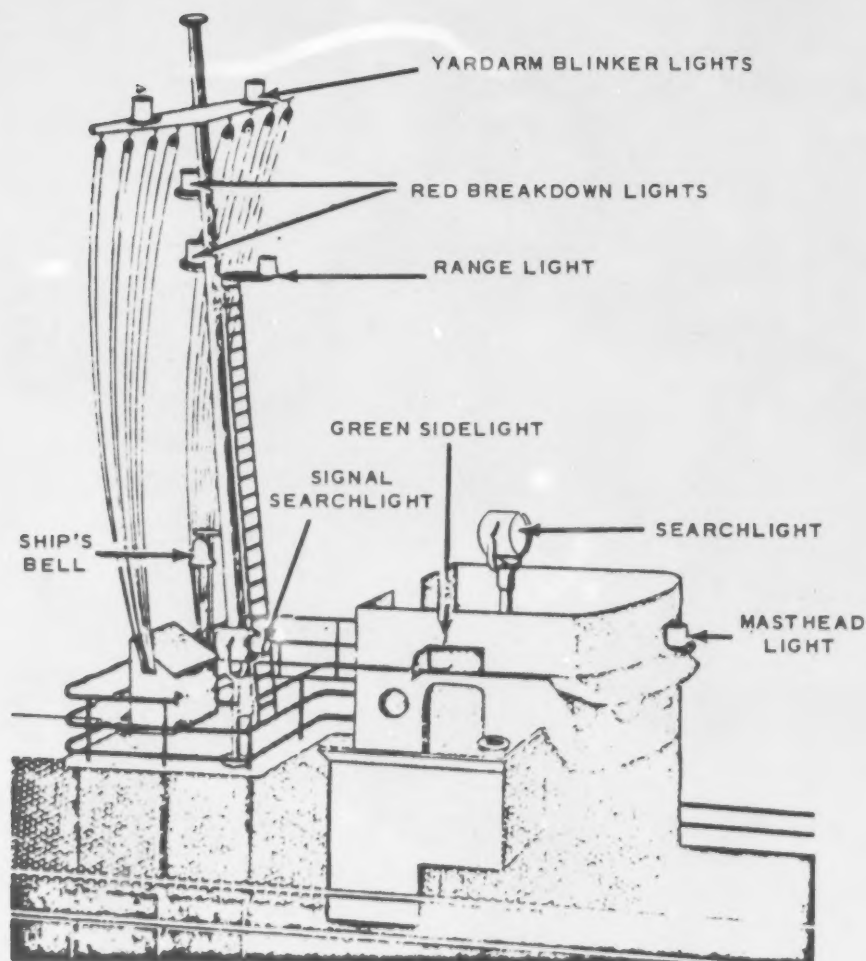
SHIP CONSTRUCTION



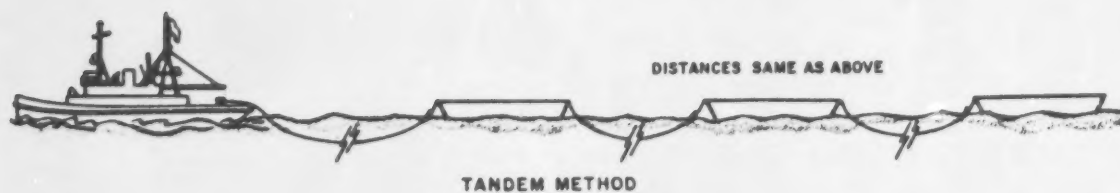
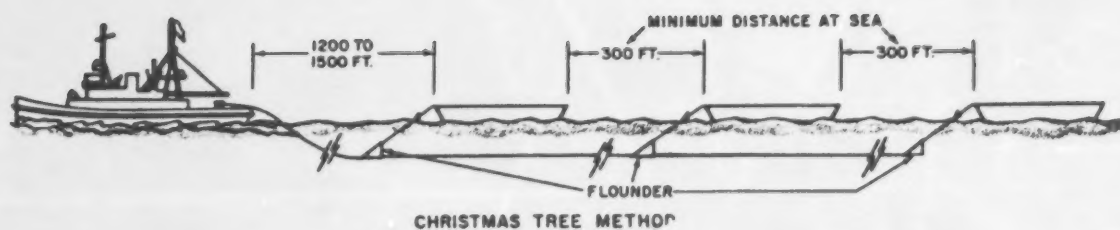
—Deck numbering system.



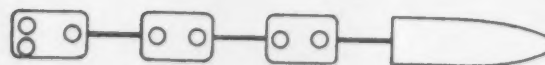
—Divisions of a ship.



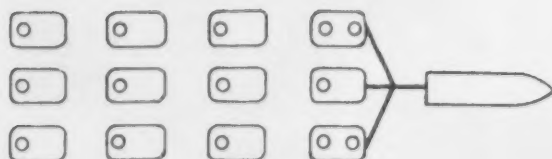
The location, number, and color of lights aboard ship follow requirements set forth in the rules of the road, the traffic rules of the sea.



Towing barges astern.



Tandem tow with hawser length
75 feet or more.



Two or more abreast in multiple
tiers.

Classification Group 1 (Type & Length of Ship)					
Type ¹	Length Designation (Load Water Line in Feet)				
	1	2	3	4	5
C Cargo	Under 400	400-450	450-500	500-550	550-600
P Passenger	Under 500	500-600	600-700	[700-800]	² [800-900]
N Coastwise Cargo	[Under 200]	[200-250]	250-300	[300-350]	[350-400]
R Refrigerated Cargo	Under 400	400-450	450-500	[500-550]	[550-600]
S Special (for Navy)	Under 200	200-300	300-400	400-500	[500-600]
T Tanker	Under 450	450-500	500-550	550-600	600-650

¹ "E-" prefix indicates an "Emergency" (as opposed to a "Long Range" type vessel; it is applied exclusively to Liberty Ship designs. *EC2-S-C1* is the standard Liberty; *EC2-S-AW1* the Liberty collier (with machinery aft).

"Z-" prefix indicates certain special conversions of standard designs, usually Liberty ships. *Z-ET1-S-C3* is a Liberty tanker (machinery 'midships); *Z-EC2-S-C5* a (boxed) airplane transport.

"B", "G", "H", "J", "K", "L", "O", "U" and "V" (tug) designations are omitted here as belonging to Great Lake, barge, coastal or inland water types not operated by MSTB.

"V-" prefix indicates a Victory Ship (VC2), an essentially emergency (Liberty) type with much greater horsepower and hull form to take advantage of it, placing it in the long range category in speed, at least.

² Bracketed lengths are theoretical; no ships have yet been built in these categories. "L6's" (Great Lake ore-grain-limestone bulk carriers) have been built, and one "P6" (superliner *United States*).

Classification of groups by type and length of ship.

Classification Group 2 (Type of Power, Number of Propellers, Passengers)						
Power	Propellers	1-12 Psgs.	13+ Psgs.	Propellers	1-12 Psgs.	13+ Psgs.
Steam	1 (Single Screw)	S	S1	2 (Twin Screw)	ST	S2
Motor (Diesel)	do	M	M1	do	MT	M2
Turbo-Electric	do	SE	SE1	do	SET	SE2
Diesel-Electric	do	ME	ME1	do	MET	ME2
Gas Turbine	do	G	(G1)	do	(GT)	(G2)

Designation of type of power, number of propellers, and number of passengers.

Design Type	Representative Tonnages		Passenger Capacity, Troop and Cabin ³	Length Overall (approximate ft.)	Beam (approximate ft.)	Speed (knots)	Horsepower (B.Brake, other Shaft)
	Cargo Capacity ¹ (DWT)	Gross Tons ² (GT)					
AKL (Army 381)	435	560	-----	176½	32	11	1,000-B
*AKL (C.G. AGL)	325	[800]	-----	180	39	12	700-B
ATA (Army 377)	219	505	-----	143½	33	12	1,000-B
C1-M-AV1	5,950	3,805	-----	339	50	10½	1,700-B
C1-M-AV1 (Trooper)	2,760	3,805	[106]	339	50	10½	1,700-B
*C1-ME2-13a	1,850	2,486	-----	266	51½	13	3,200-B
C2-S-B1(R)	7,541	8,165	-----	459	63	15½	8,500
C3-S-A1 (Carrier)	5,005	15,942	-----	465	69½	16½	8,500
C3-ST-14a	10,111	13,792	-----	499	78	18	12,000
C4-S-A1 (Trooper)	6,125	13,000	2,600	523	71½	17	9,000
C4-S-B1 (Heavy Lift)	13,468	11,164	-----	520	71½	17	9,000
C4-S-B5 (Heavy Lift)	13,805	10,851	-----	520	71½	17	9,000
LSD (Reconstructed)	* 6,000	8,050	-----	475	72	15½	6,100
LSM (Navy)	575	(575)	-----	203½	34½	9½	2,880-B
LST (Navy or S3-M2-K2)	[2,455]	[2,200]	-----	328	50	10	1,800-B
P2-S1-DN3	6,934	13,319	1,600	534	73	(19)	12,500
P2-S2-R2	8,929	17,806	2,000	622	75½	(19)	17,000
P2-SE2-R1	9,944	16,039	1,700	609	75½	19	18,000
R1-M-AV3	5,213	3,777	-----	339	58	10½	1,700-B
*S2-ST-23a	4,157	4,220	-----	465½	74	15	6,000
*T1-MET-24a	3,445	3,459	-----	302	61	12	4,000-B
T1-M-BT2	4,000	3,160	-----	325	48	10	1,400-B
T2-SE-A1	16,500	10,296	-----	523½	68	14½	6,000
T2-SE-A2	16,350	10,461	-----	523½	68	16	10,000
T5-S-12a	25,192	15,626	-----	620	83½	18	18,600
T5-S-RM2a	22,908	15,000	-----	615	80	20	20,000
VC2-S-AP2	10,681	7,606	-----	455	62	15½	6,000
VC2-S-AP3	8,300	7,771	-----	455	62	16½	8,500

¹ "Deadweight Tonnage": total capacity in long tons (2,240 lbs), not including vessel's weight (applied especially to freighters and tankers).

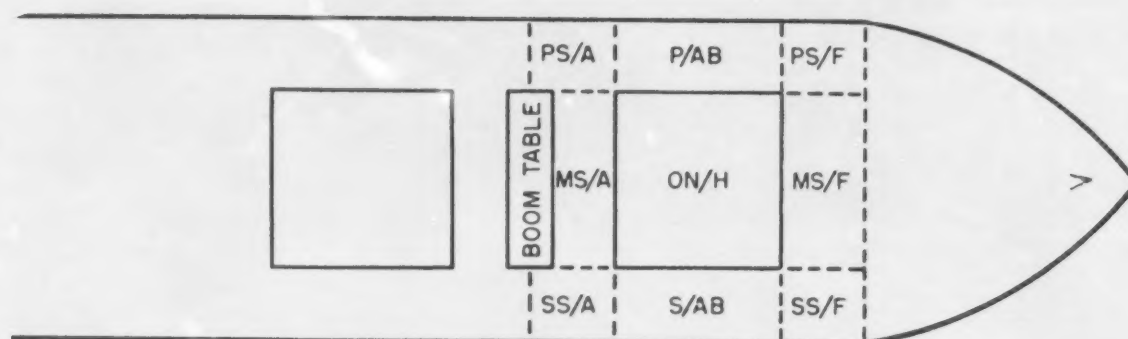
² "Gross Tonnage": measurement "tons" of 100 cu. ft. of permanently enclosed space, not a weight either of ship or cargo.

³ Passenger figures very approximate; individual ship capacities vary greatly, change often.

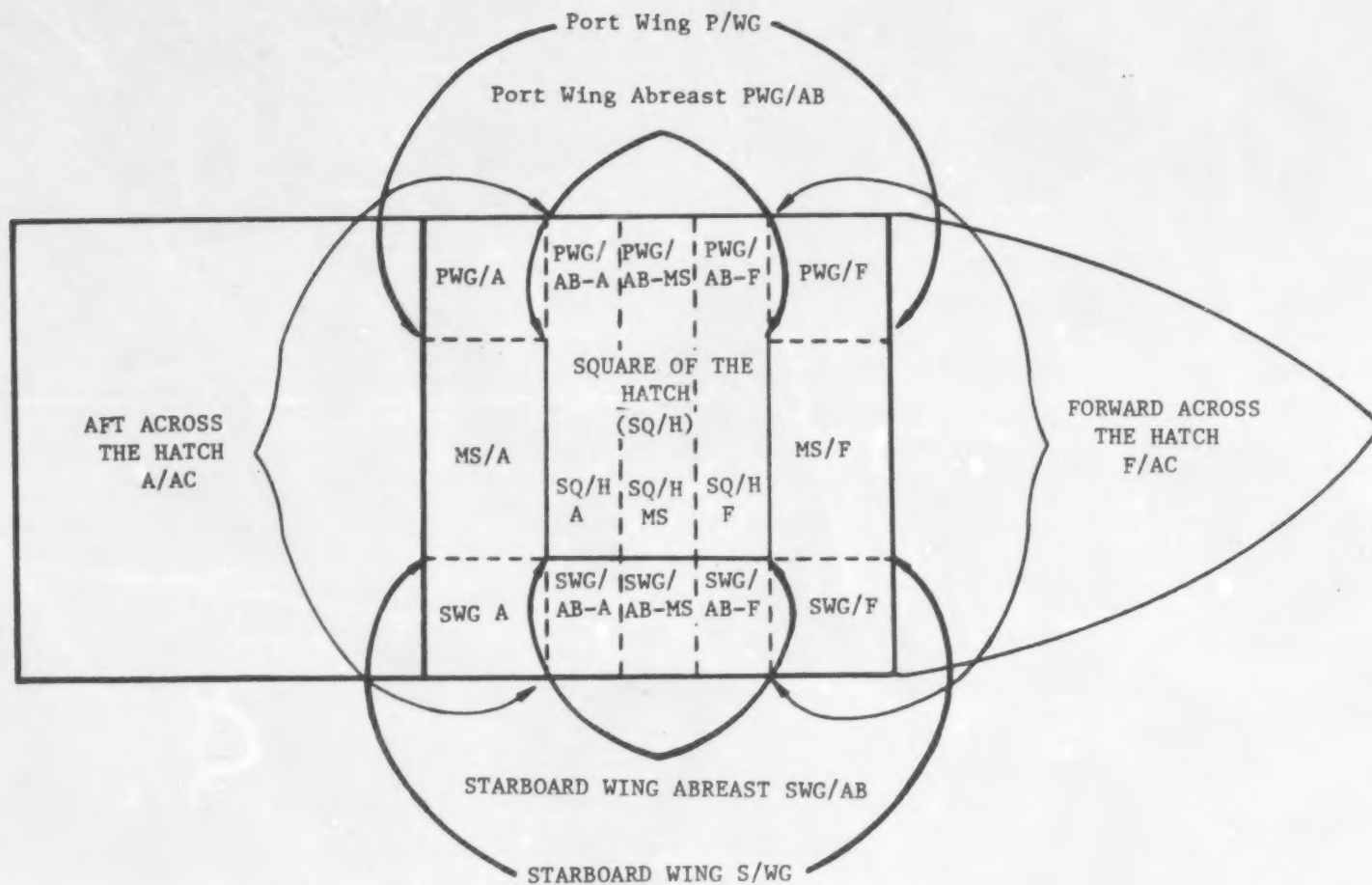
⁴ Add 10 percent to "normal" shaft horsepower here for standard ABS rating.

N.B.: Bracketed figures are estimated. *Ice strengthened.

Ship design types and their characteristics.



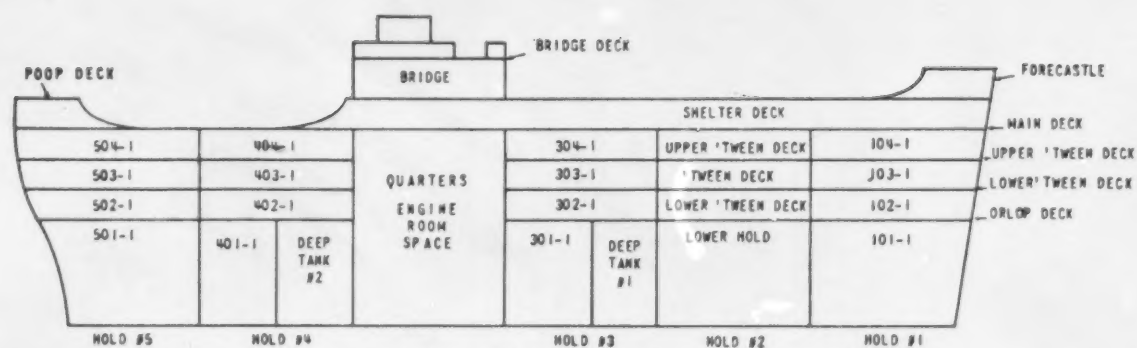
Main deck stowage plan.



Hold stowage plan.

742

743



NUMBERING OF HOLDS USED ON WATCH LIST

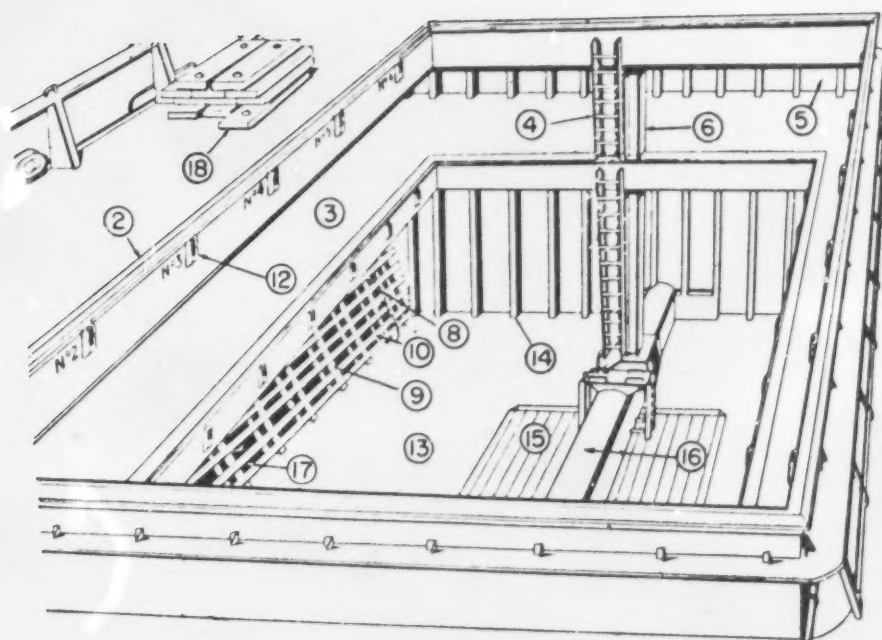
101-1 (#1 L/N FIRST SHIPMENT INTO HATCH AND LOADED INTO LOWER HOLD.

101-2 (#1 L/N SECOND SHIPMENT INTO HATCH AND LOADED INTO LOWER HOLD.

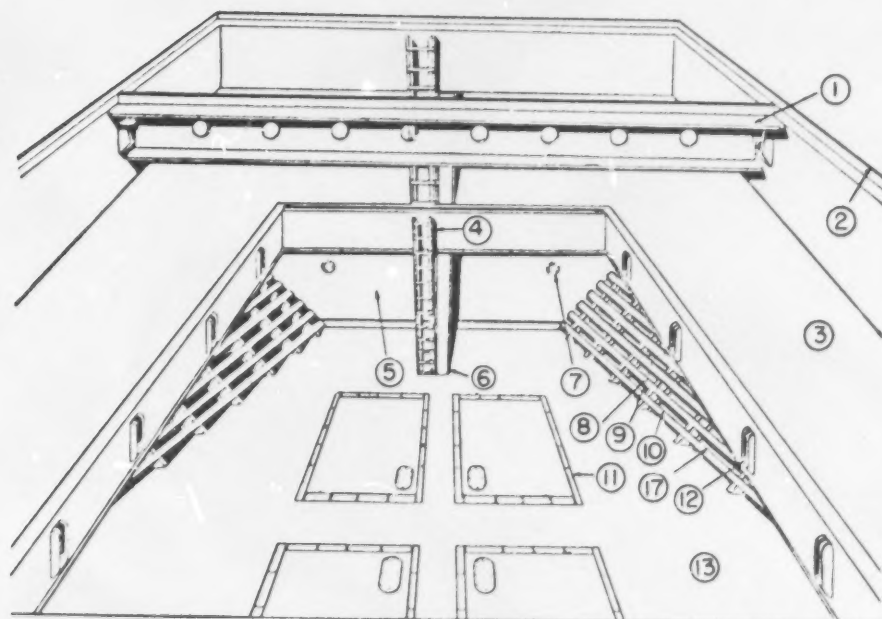
KEY:

THE FIRST NUMBER DESIGNATES THE HOLD, THE SECOND NUMBER IS ZERO & CONSTANT. THE THIRD NUMBER DESIGNATES THE HOLD STARTING WITH THE LOWER HOLD AND NUMBERED UPWARD. THE NUMBER FOLLOWING THE DASH INDICATES THE LOT NUMBER OF THE SHIPMENT.

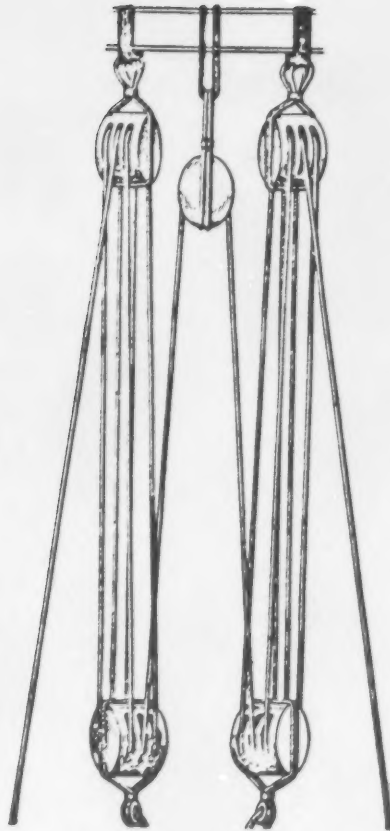
Locations of decks and holds.



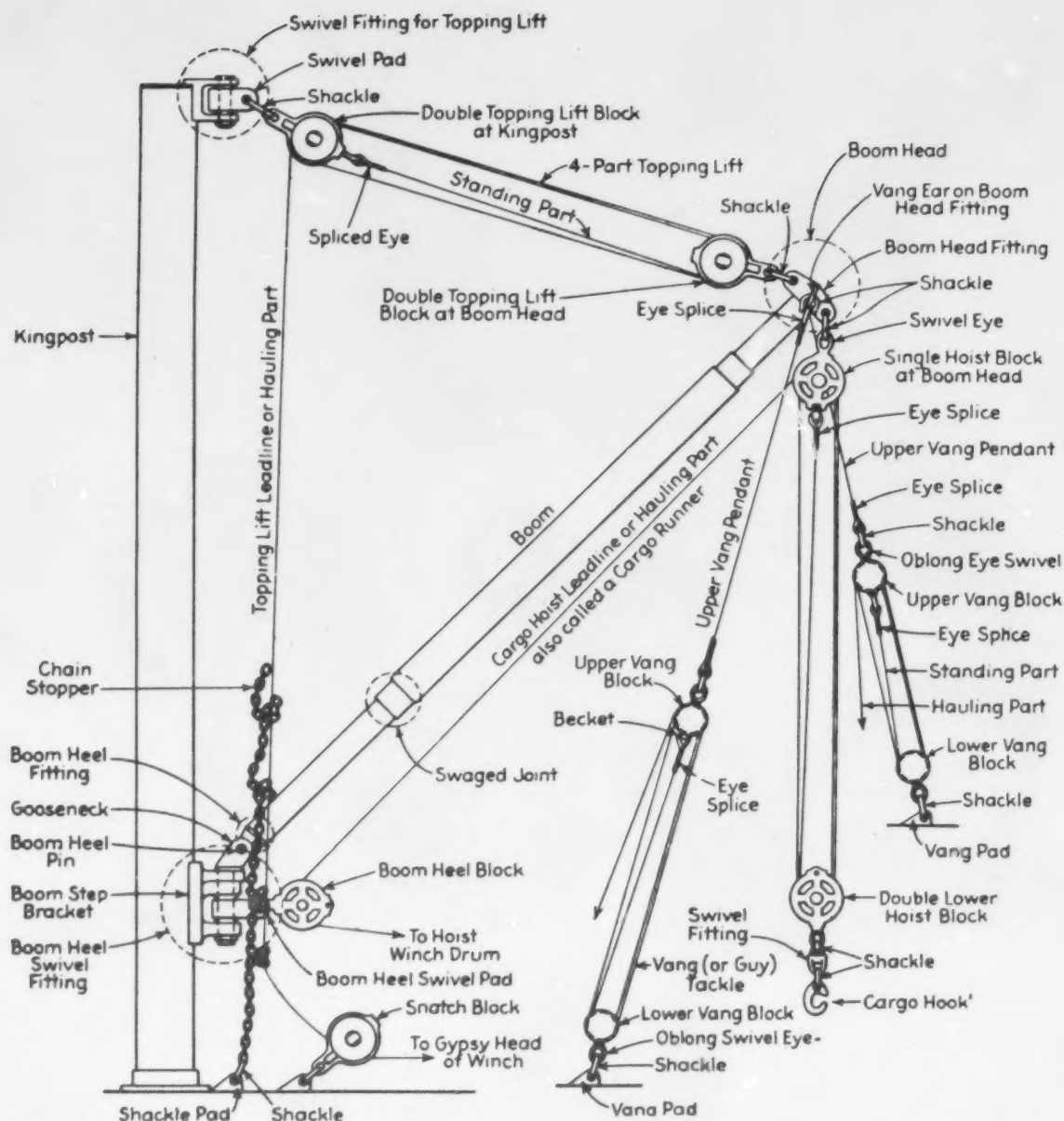
After hold on old style cargo ship.



Forward hold on old style cargo ship.

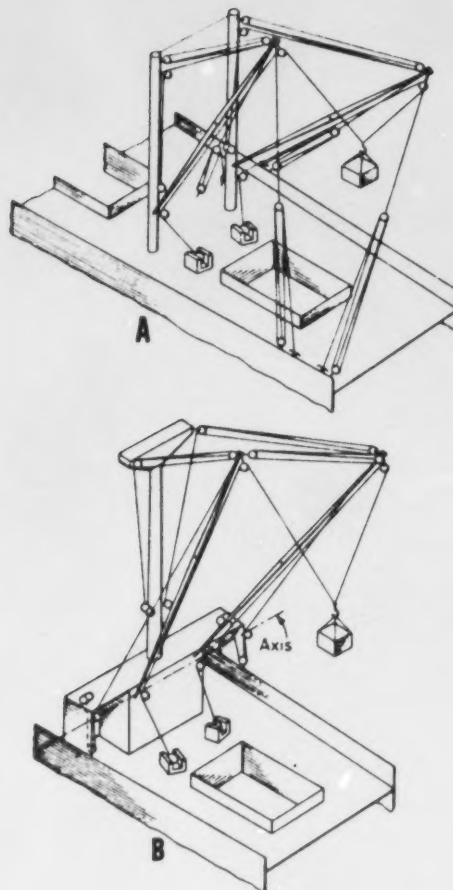


Rigging two tackles with a continuous fall.



Courtesy of The Society of Naval Architects and Marine Engineers, Design and Construction of Steel Merchant Ships.

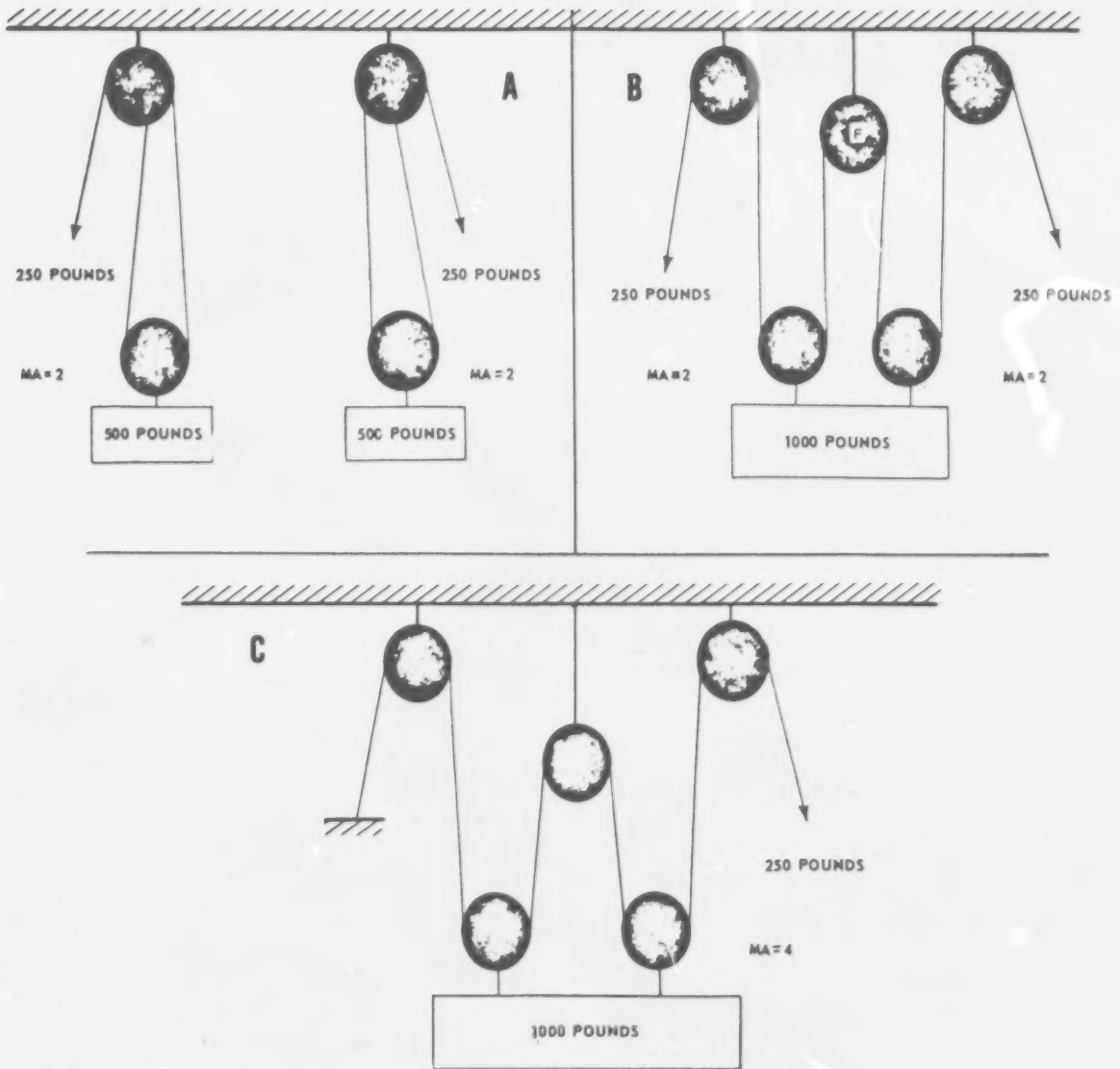
Single swinging boom.



*Courtesy of The Society of Naval Architects and
Marine Engineers, Design and Construction of
Steel Merchant Ships.*

Burtoning rig.

- A. Conventional vang;
- B. Coaxial vang.



Advantages of a Spanish burton rig.

Flight Planning

Objective:

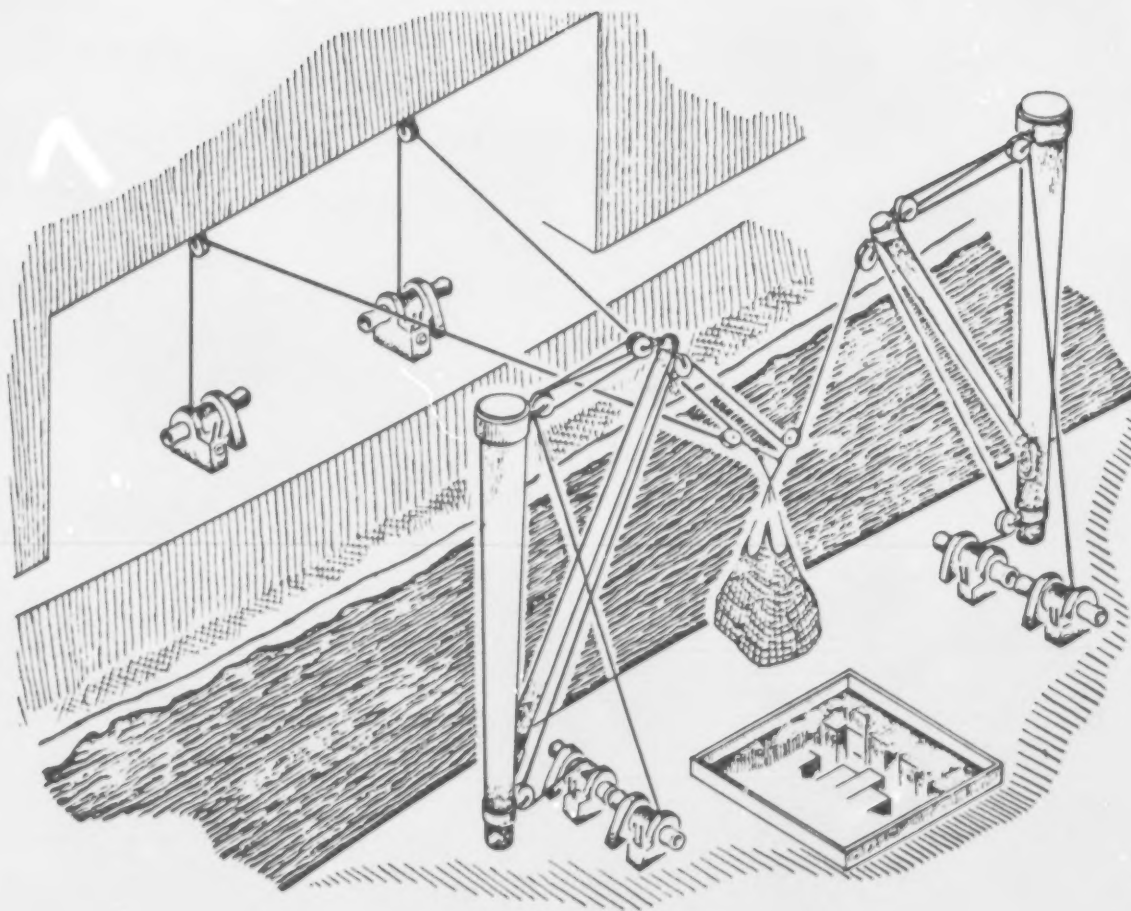
You will take the materials given and correctly file a flight plan and complete a flight log.

Materials:

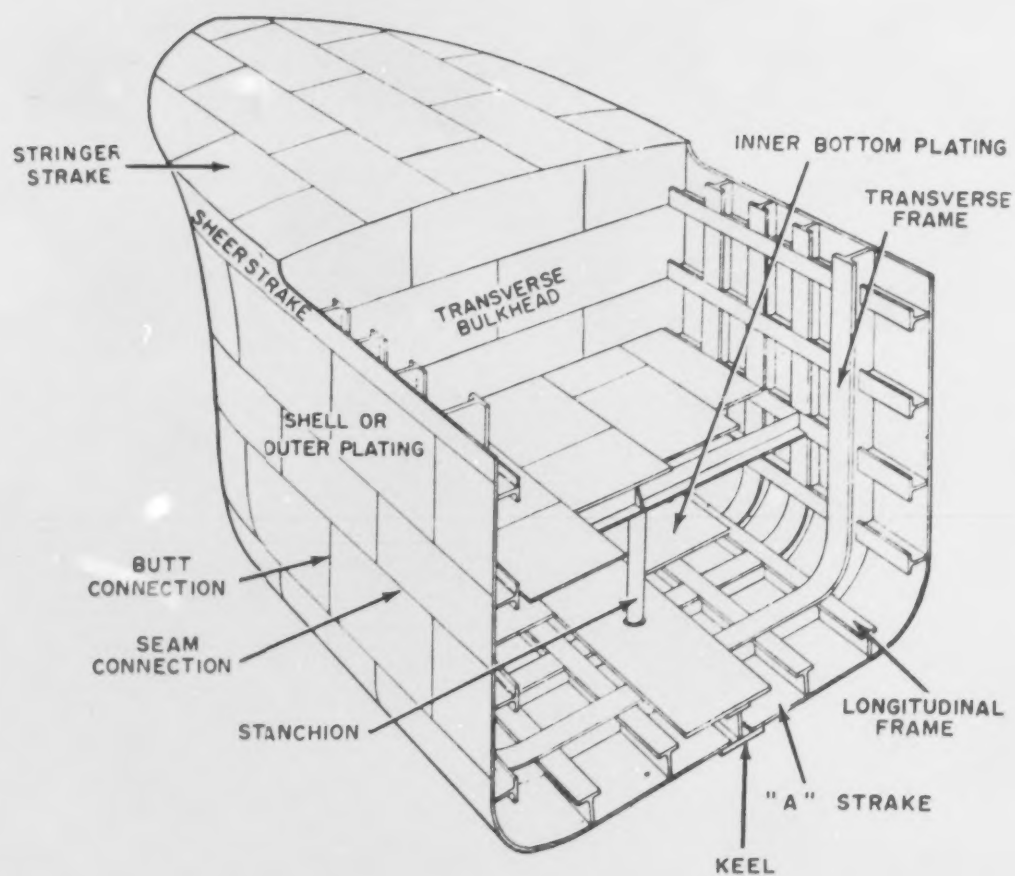
1. Map from Activity #2.
2. Flight plan sheet.
3. Flight log.

Procedure:

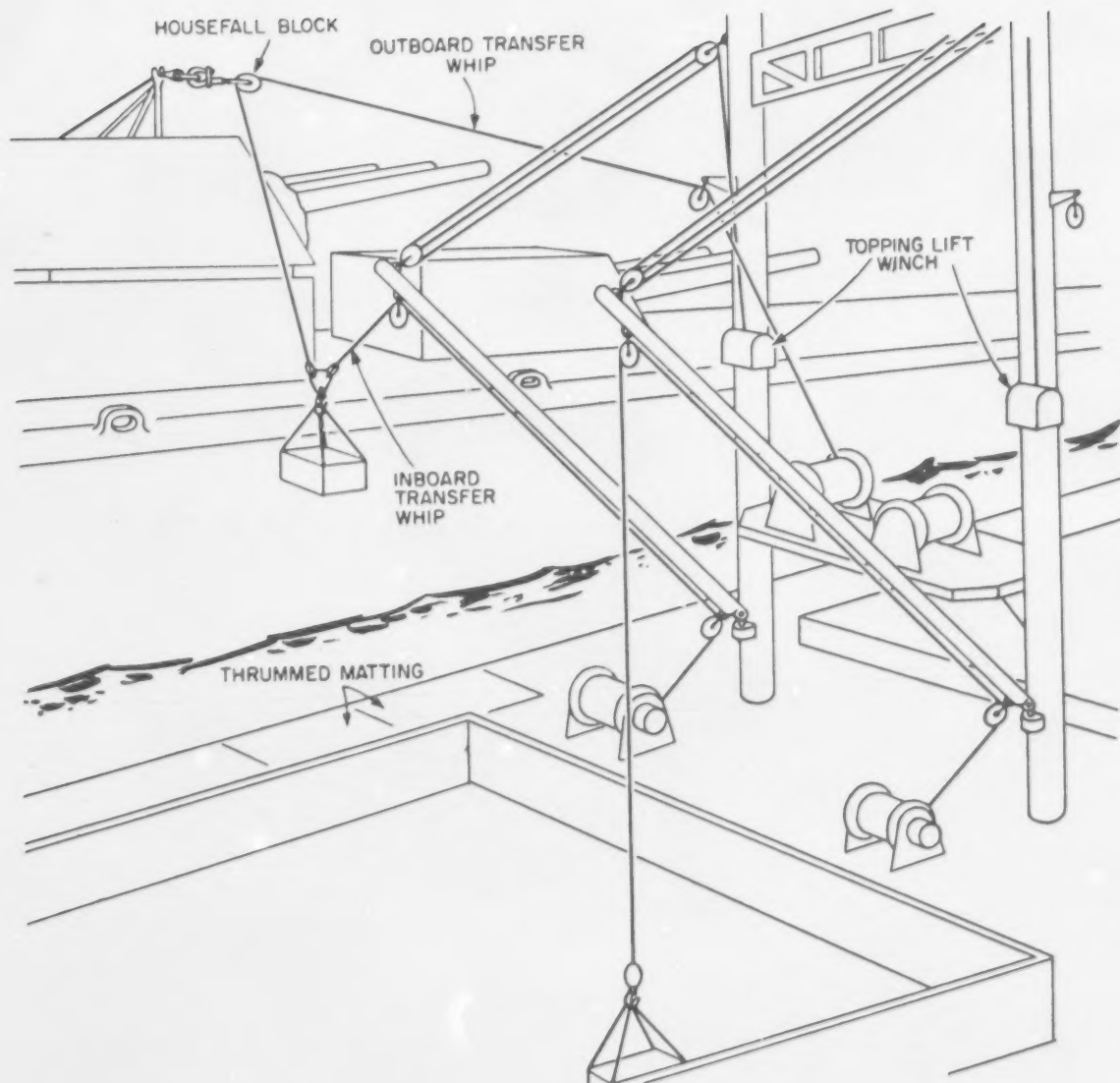
1. Determine a route of flight you desire to make using the map from Activity II.
2. Complete the flight log by correctly filling in the blanks. Use zero wind and estimate your ground speed as 120 knots. The distance given on aeronautical charts is in nautical miles. A knot is nautical miles per hour.
3. Complete the flight plan by correctly filling in the blanks. DVFR is a VFR flight plan requiring an ATC clearance. Do not use this block.
4. Submit flight plan and log to your instructor for evaluation.



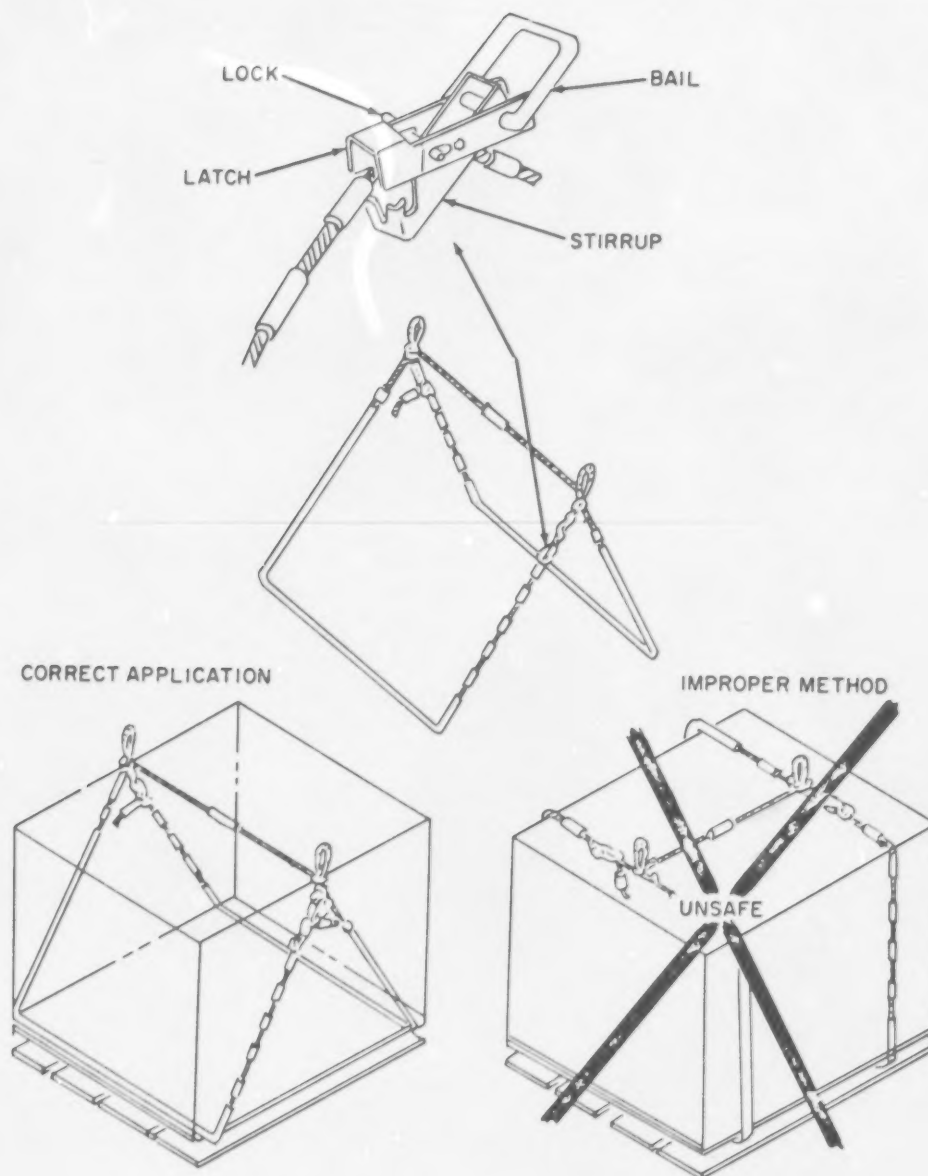
Basic doubled-up burton rig.



The ship's basic structure.



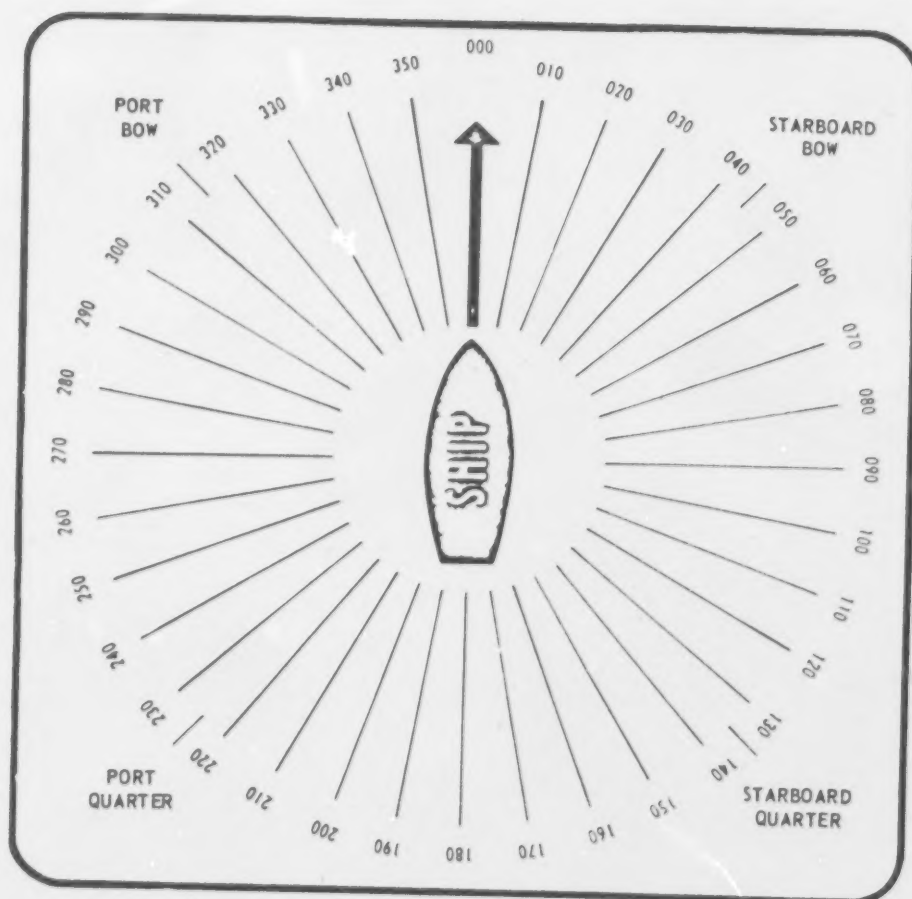
Basic housefall rig



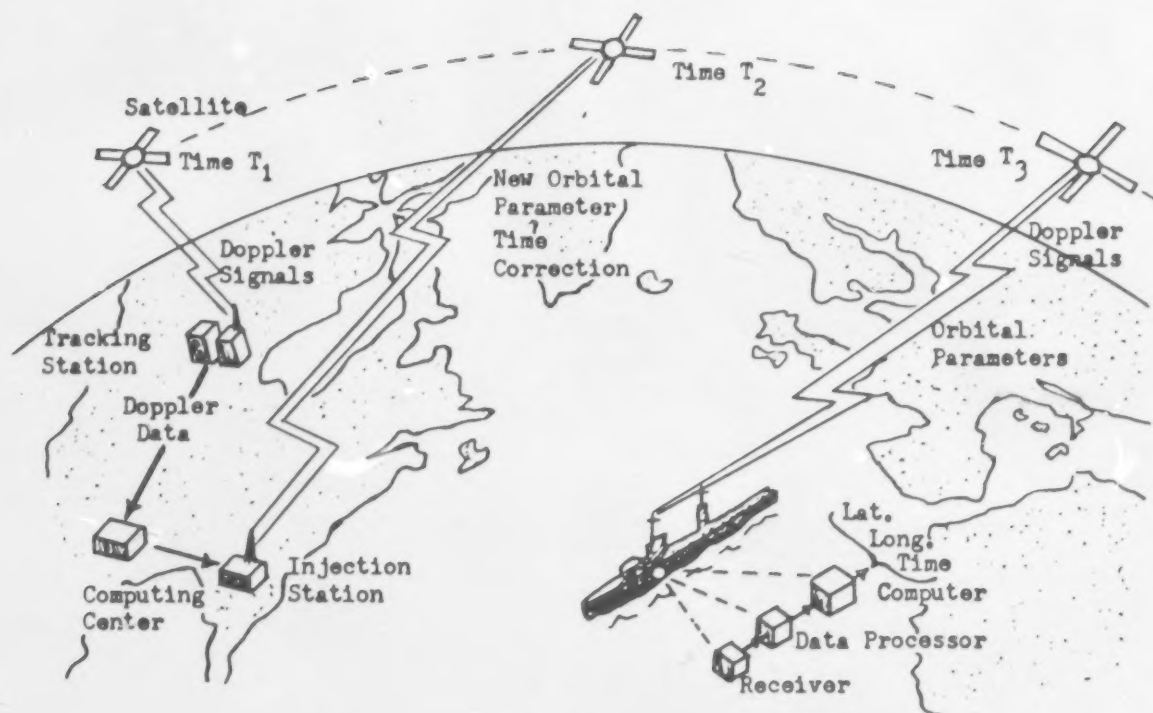
Adjustable pallet sling.

The four available sizes of adjustable slings are color-coded as follows:

Red	For loads 13 to 31 inches high;
Black	For loads 29 to 40 inches high;
Green	For loads 36 to 50 inches high; and
Yellow	For loads 48 to 70 inches high.



-Relative bearings.



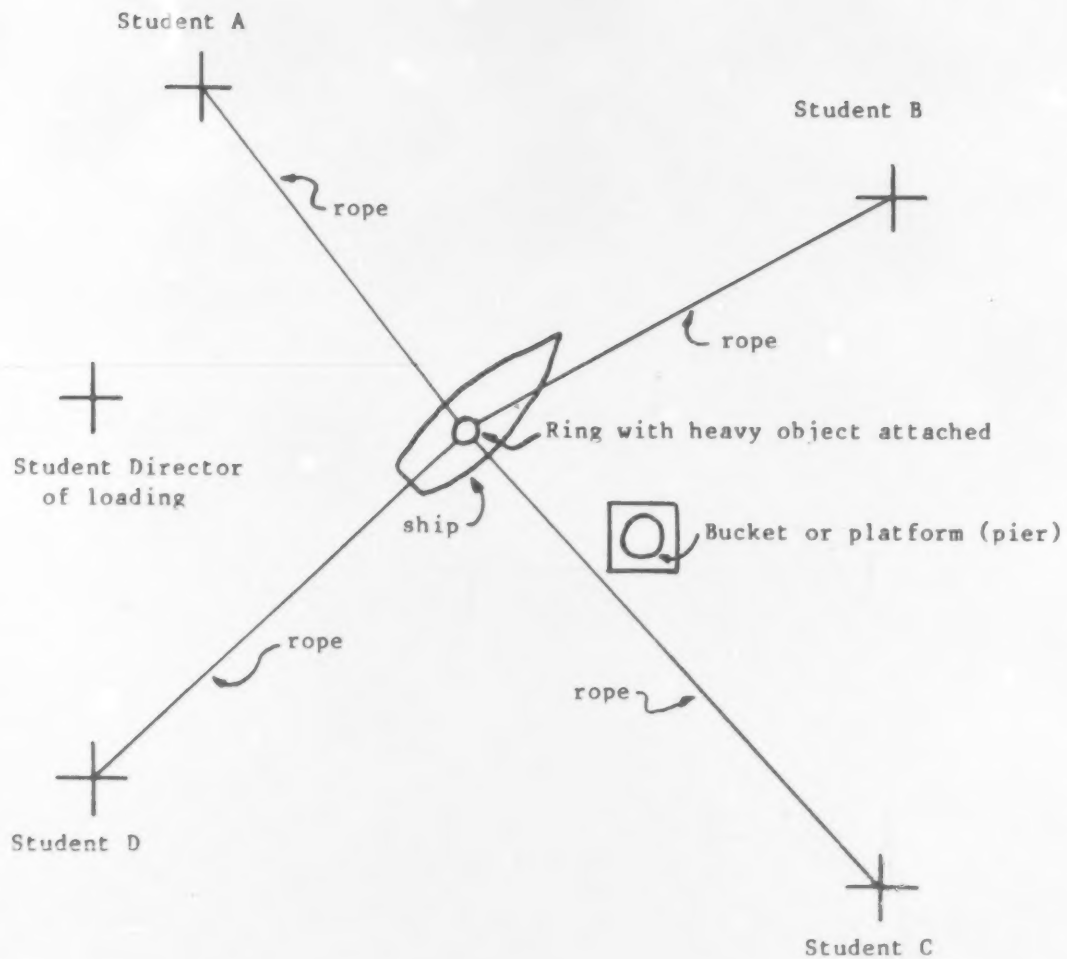
STUDENT ACTIVITY 1

Rigging Exercise

WT 3.32

Object:

Student director tells students A, B, C, & D when and how hard to pull to lift cargo from ship deck to platform on pier without dropping it (touching the floor) into the water.



STUDENT ACTIVITY 2

Determining Mechanical Advantage (MA) of Rigging

Principle:

The more times you have a line lifting an object the less force it takes to lift it.

Reference:

Transparency Master #19

Materials:

1. 20 feet of small clothesline rope or venetian blind cord.
2. Five 1" or 2" pulleys with swivels (available in hardware stores).
3. Small fish weighing scale.
4. Small heavy object to lift.
5. Net citrus fruit bag to serve as a cargo net.

Procedure:

1. Attach net around heavy object (cargo).
2. Attach scale to object and lift it.
3. Record weight of object.
4. Attach rope to object and put rope through pulley above object. Connect scale to end of rope and lift object. (See Fig. 1)
5. Record weight on scale and determine MA.
6. Attach pulley to net and place rope and scale as shown in Figure 2 and lift object.
7. Record weight on scale and determine MA.
8. Rig pulleys as shown in Figures 3, 4, and 5.
9. Lift weight after each additional pulley is added.
10. Record weight on scale and determine MA.

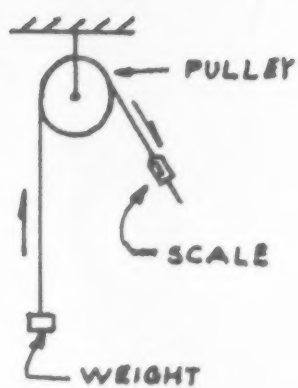


Fig. 1

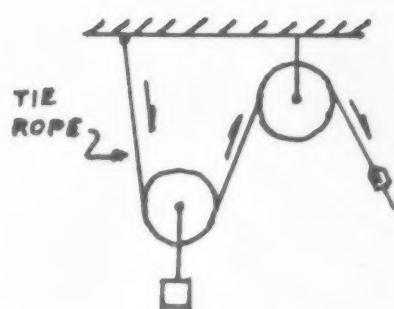


Fig. 2

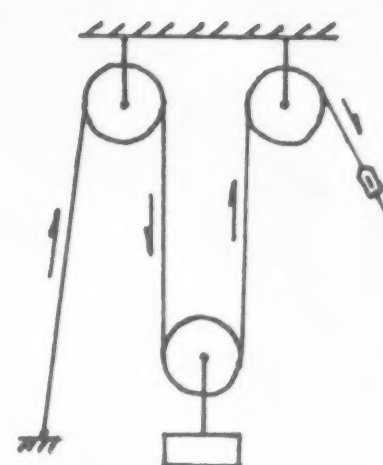


Fig. 3

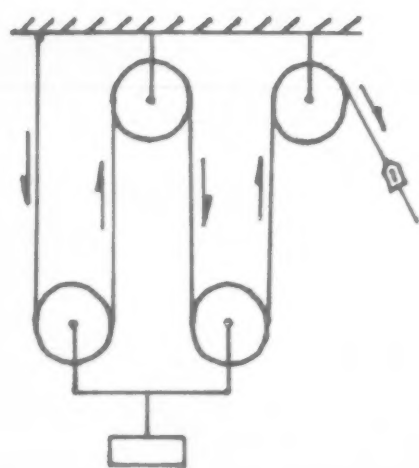


Fig. 4

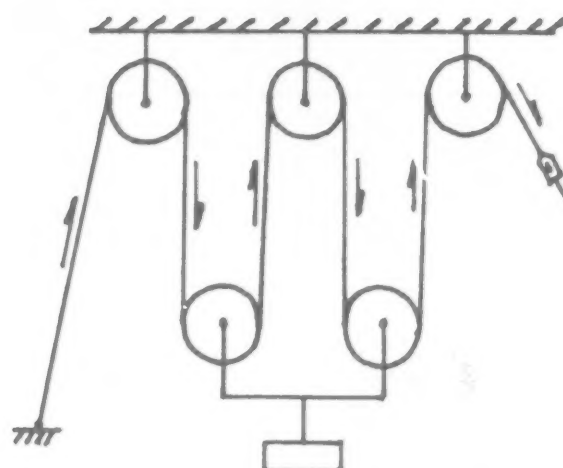


Fig. 5

STUDENT ACTIVITY 3

Design and construct a crane from an erector set (or make the parts from wood or metal) to load and unload cargo from model ships.

1. Use net orange sacks for cargo nets.
2. Make pallets of wood and slings (TM #23) to lift cargo.
3. Students may bring toy tractor-trailer (semi) trucks to use as containerized cargo units.

STUDENT ACTIVITY 4

Go to the library and get the Dictionary of Occupational Titles and look up the following job titles and write the job description.

1. Shipfitter
2. River and harbor supervisor
3. Master
4. Marine mechanics and repairers
5. Ship and boat building

STUDENT ACTIVITY 5

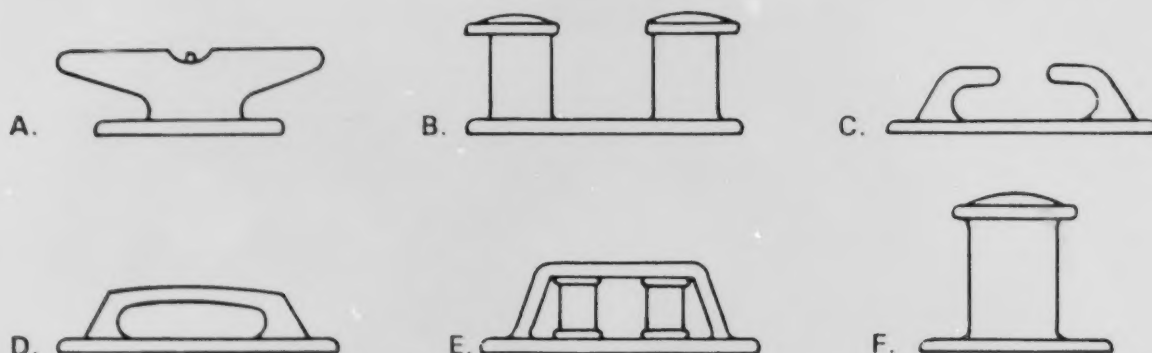
WT 3.37

Deck Fittings and Mooring Lines

Whenever a ship comes into port, liberty for the crew doesn't begin until the vessel is securely tied up. For large ships, this evolution may take several hours.

Identify these deck fittings and mooring lines to test your knowledge of seamanship. If you're a deck hand, it'll be easy. But, if you're among those sailors who always stand by waiting to "hit the beach," this test may not be so easy.

Deck Fittings:



Mooring Lines:



- | | |
|----|---------------------------|
| 1. | a. after quarter spring |
| 2. | b. waist breast |
| 3. | c. bow line |
| 4. | d. after bow spring |
| 5. | e. forward bow spring |
| 6. | f. stern line |
| 7. | g. forward quarter spring |

ADDITIONAL STUDENT ACTIVITIES

1. Have students bring in a compass and relate it to navigation systems.
2. Demonstrate a gyro.
3. Build a ship and wire the running lights. (TM #8)
4. Design and build a model cabin (room) on a cruise liner (to scale).
5. Design and build a model cruise liner.
6. Construct a cargo hold of sheetmetal and wood and make it watertight (solder).
7. Rig a model ship to tow barges.
8. Make the booms and buy pulleys and clothesline to make some of the different kinds of cargo rigging.
9. Have geography teacher point out stars which are used for navigation.
10. Write for a copy of the book "U.S. Navy Films for Public Use" and request appropriate films.
11. Write for the "Caralog of Nautical Charts" and order a chart (map) of some harbor. Have students draw a similar map.
12. Take field trips to:
 - local travel agency
 - local planetarium
 - local cargo handling terminals
13. Invite Navy recruiter to come talk to class and tell about the many technical job opportunities in the Navy.
14. Have students buy model ships and put them together to form a display of ocean transportation at school or in a local store window. Show jobs such as welder, pipefitter, electrician, sheet metal worker, etc.

WT 3.39

TEST 1

Ship Construction Stages

Place in proper order the stages in building a ship.

_____ Conceptual Design

_____ Inception

_____ Working Drawings

_____ Contract Design

ANSWERS TO TEST 1

Ship Construction Stages

2 Conceptual Design

1 Inception

4 Working Drawings

3 Contract Design

TEST 2

Ocean Transportation Terms

Match terms with definitions:

- | | |
|--|---------------------|
| _____ 1. Name for space below deck where cargo is stored. | A. Tonnage |
| _____ 2. Loading ship cargo into the trailer section of a tractor-trailer truck and placing the trailer onto the ship. | B. Cargo |
| _____ 3. A symbol on the side of the ship that shows when a ship is fully loaded when the water reaches the symbol. | C. Deck |
| _____ 4. A navigation device used to measure the altitude of the stars, sun and moon above the horizon. | D. Hold |
| _____ 5. Two categories: dry and liquid. | E. Containerization |
| _____ 6. Storage space on a ship not used. | F. Sextant |
| _____ 7. A platform forming parts of the ships girders going horizontally across the ship. | G. Plimsoll Mark |
| _____ 8. A ship's ability to operate in all kinds of weather, wind, and seas. | H. Seaworthiness |
| _____ 9. Ability of a ship to return to an upright position when tipped to one side by wind or waves. | I. Stability |
| _____ 10. Weight of cargo a ship can carry. | J. Broken Storage |

ANSWERS TO TEST 2

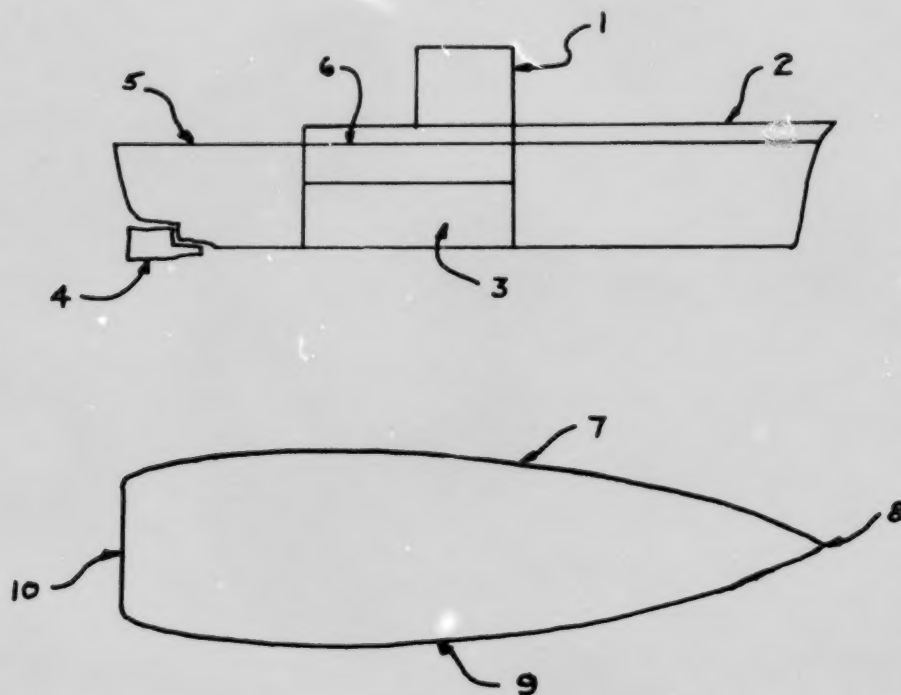
Ocean Transportation Terms

1. D
2. E
3. G
4. F
5. B
6. J
7. C
8. H
9. I
10. A

TEST 3

Parts of a Ship

Match number where arrow points to the correct name of the part of the ship. (See Transparency Masters 5, 6, 7)



- _____ Fantail
- _____ Forecastle
- _____ Superstructure
- _____ Port Side
- _____ Stern

- _____ Starboard Side
- _____ Rudder
- _____ Bow
- _____ Boiler & Machinery Spaces
- _____ Main Deck

ANSWERS TO TEST 3

Parts of a Ship

- 5 Fantail
- 2 Forecastle
- 1 Superstructure
- 7 Port Side
- 10 Stern
- 9 Starboard Side
- 4 Rudder
- 8 Bow
- 3 Boiler & Machinery Spaces
- 6 Main Deck

TRANSPORTATION

JOB STRUCTURE: WATER

JOB TITLE: Port Captain

D.O.T. No.: 184 167 182

Major Job Function:

Manages on-shore activities for company vessels.

Job Duties:

1. Reads radio messages from ship master to determine services requested.
2. Requisitions ship's stores or equipment to be delivered on dock at vessel's arrival.
3. Places orders for fuel oil and arranges for time of delivery.
4. Orders personnel replacements from unions.
5. Arranges for other services, such as inspections, tests, overhauls, as required by federal regulations or by company.
6. Notifies shipmaster by radio of arrangements made.

JOB TITLE: Marine Engineer

D.O.T. No.: 197 130 010

Major Job Function:

Supervises and coordinates activities of crew engaged in operating and maintaining propulsion engines and other engines, boilers, deck machinery, and electrical, refrigeration, and sanitary equipment aboard ship.

Job Duties:

1. Inspects engines and other equipment and orders crew to repair or replace defective parts.
2. Starts engines to propel ship and regulates engines and power transmission to control speed of ship.

JS WT 1

Marine Engineer Job Duties (continued):

3. Stands engineroom watch during specified periods, observing that required water levels are maintained in boilers, condensers, and evaporators, load on generators are within acceptable limits, and oil and grease cups are kept full.
4. Repairs machinery, using handtools and power tools.
5. Maintains engineering log and bell book (orders for changes in speed and direction of ship).

JOB TITLE: Mate

D.O.T. No.: 197 133 022

Major Job Function:

Supervises and coordinates activities of crew aboard ship.

Job Duties:

1. Inspects holds of ship during loading to insure that cargo is stowed according to specifications.
2. Examines cargo-handling gear and lifesaving equipment and orders crew to repair or replace defective gear and equipment.
3. Supervises crew engaged in cleaning and maintaining decks, superstructure, and bridge of ship.
4. Stands watch during specified periods and determines geographical position of ship, upon request of ship master, using loran and azimuths of celestial bodies.
5. Assumes command of ship in event ship master becomes incapacitated.

JOB TITLE: Ship Pilot

D.O.T. No.: 197 133 026

Major Job Function:

Commands ships to steer them into and out of harbors, estuaries, straits, and sounds, and on rivers, lakes, and bays.

Ship Pilot Job Duties:

1. Directs course and speed of ship on basis of specialized knowledge of local winds, weather, tides, and current.
2. Orders worker at helm to steer ship, and navigates ship to avoid reefs, outlying shoals, and other hazards to shipping, utilizing aids to navigation, such as lighthouses and buoys.
3. Signals tugboat captain to berth and unberth ship.
4. Must be licensed by U.S. Coast Guard with limitations indicating class and tonnage of vessels for which license is valid and route any waters that may be piloted.

JOB TITLE: Tugboat Captain

D.O.T. No.: 197 133 030

Major Job Function:

Commands tugboat to tow barges and ships into and out of harbors, estuaries, straits, and sounds, and on rivers, lakes, and bays.

Job Duties:

1. Signals workers on deck to rig towlines to barges or ship to be towed.
2. Determines course and towing speed on basis of specialized knowledge of local winds, weather, tides, and current.
3. Steers tugboat to push or pull barges to destination and to berth and unberth ships, avoiding reefs, outlying shoals, and other hazards to shipping, utilizing navigation devices, such as radar, sonic depth finder, compass and sextant and aids to navigation, such as lighthouses and buoys.
4. Directs placement of suction hose or siphon to pump water from hold of barge, and signals workers to repair leak.
5. Is required to hold license issued by U.S. Coast Guard.

JS WT 4

JOB TITLE: Tugboat Mate

D.O.T. No.: 197 133 034

Major Job Function:

Supervises and coordinates activities of crew aboard tugboat.

Job Duties:

1. Inspects towing gear and lifesaving equipment, and orders crew to repair or replace defective equipment.
2. Directs activities of crew engaged in rigging towlines to barges or ship to be towed.
3. Supervises crew engaged in cleaning and painting of boat.
4. Stands watch during specified periods, and determines geographical position of boat upon request of tugboat captain, using loran and azimuths of celestial bodies.
5. Steers tugboat, upon request of tugboat captain to push or pull barges to destination and to berth and unberth ships, avoiding reefs, outlying shoals, and other hazards to navigation, utilizing navigation devices, such as compass and sextant, and aids to navigation, such as lighthouses and buoys.
6. Assumes command of tugboat in event tugboat captain becomes incapacitated.
7. Is required to hold license issued by U.S. Coast Guard.

JOB TITLE: Ferryboat Captain

D.O.T. No.: 197 163 010

Major Job Function:

Commands ferryboat to transport passengers, motor vehicles, or freight across lakes, bays, sounds, or rivers.

Job Duties:

1. Signals crew to close ferry gates and raise loading ramp, and signals engineroom to start engines.
2. Determines course and speed of ferryboat on basis of specialized knowledge of local winds, weather, tides, and current.

Ferryboat Captain Job Duties (continued):

3. Steers ferryboat, or orders worker at helm to steer ferryboat toward ship on opposite side of water.
4. Inspects ferryboat to insure that passengers and crew observe regulations pertaining to safe and efficient operation of ferryboat.
5. Signals engineroom to reverse engines, and maneuvers ferryboat into ship.
6. Maintains ferryboat's log.
7. Must hold license issued by U.S. Coast Guard depending on tonnage of ferryboat and waters crossed.

JOB TITLE: Purser

D.O.T. No.: 197 167 014

Major Job Function:

Coordinates activities of workers aboard ship concerned with ship-board business functions and social activities for passengers.

Job Duties:

1. Prepares shipping articles and signs on crew.
2. Maintains payroll records and pays off crews at completion of voyage.
3. Submits passenger and crew sailing lists to governmental agencies as required by regulations.
4. Assists passengers in preparing declarations for customs, arranging for inspections of horticultural items being brought into country, and inspections of documents by immigration authorities.
5. Prepares ship's entrance and clearance papers for foreign ports, and ship's cargo manifests when discharging cargo.
6. Supervises stowage, care, and removal of hold baggage.
7. Arranges for travel and scenic tours at ports of call.

JS WT 6

Purser Job Duties (continued):

8. Provides banking services and safekeeping of valuables for passengers.
9. Supervises preparing, editing, printing, and distribution of ship's daily newspaper.
10. Plans and conducts games, tournaments, and parties for passengers' enjoyment.

JOB TITLE: Freight Rate Analyst

D.O.T. No.: 214 267 010

Major Job Function:

Analyzes existing freight rates, tariff regulations, and proposed or government-approved changes in rates to revise or recommend changes in rate structures, rules, and regulation for freight carried.

Job Duties:

1. Analyzes proposals and applications for changes in rates, rules, or regulations received from rate bureaus, shippers, sales offices, and other carriers, and reviews regulations and regulatory agencies' decisions on applications filed by other carriers governing established rates and newly approved rate changes to determine required changes in company's rate charts.
2. Compiles rate-manual sections in accordance with governmental regulations, based on factors such as handling costs, classes of merchandise transported, fuel costs, refrigeration required, business volume, and potential return trip loads.
3. Confers with shippers, sales and rate bureau personnel, and others to discuss revised rates, rules, and regulations.
4. Prepares revised rate schedules or submits data for publication.

JOB TITLE: Ship Runner

D.O.T. No.: 222 567 014

Major Job Function:

Determines location for merchandise on dock preparatory to being stowed on ship or transported to receivers.

Ship Runner Job Duties:

1. Inspects freight to determine amount of dock space freight will occupy.
2. Directs movement and disposition of freight on dock.
3. Marks destination of outgoing freight in large letters on dock, using chalk.
4. Records deliveries in record book.

JOB TITLE: Mess Cook

D.O.T. No.: 315 371 010

Major Job Function:

Cooks and serves meals to crew on passenger ship.

Job Duties:

1. Cleans, cuts, and cooks meat, fish, and poultry.
2. Serves food to crew members.
3. Washes dishes and cleans galley and galley equipment.
4. Requisitions supplies.
5. Compiles cost records of food used.

JOB TITLE: Scullion

D.O.T. No.: 318 687 014

Major Job Function:

Performs any combination of tasks involved in cleaning ship's galleys, bakery, and butcher shop.

Job Duties:

1. Cleans pots and pans, dishes, chopping blocks, and service stations, by hand or using dishwashing machine.
2. Polishes silver chafing dishes and coffee pots.

JS WT 8

Scullion Job Duties (continued):

3. Places washed glasses in rack to prevent breakage.
4. Defrosts and cleans reefers and iceboxes.
5. Cleans and culls vegetables and fruits.
6. Dumps garbage and cleans can.
7. Swabs deck of assigned area.
8. Carries supplies from reefers and storerooms to galleys, pantries, bakery, and butcher shop.
9. Stocks serving stations with dishes and stores.

JOB TITLE: Steward/Stewardess

D.O.T. No.: 350 677 022

Major Job Function:

Attends to comfort of passengers aboard ship.

Job Duties:

1. Issues sun pads and sports equipment to passengers on deck.
2. Arranges card tables and chairs and provides playing cards, pencils, and score pads for passengers in lounge.
3. Carries passenger's baggage to assigned rooms, and cleans rooms, changes linens and towels, and makes up beds and berths.
4. Issues and arranges game equipment for passengers in smoking room.
5. Serves cold drinks and snacks to passengers.

JOB TITLE: Marine Engine Machinist

D.O.T. No.: 623 281 026

Major Job Function:

Install and repairs gasoline and diesel engines in boats, such as yachts, tugs, and trawlers, following specifications.

Marine Engine Machinist Job Duties:

1. Positions engine over mounting holes, using chain hoist.
2. Bolts engine to mount and straps fuel tank to cradle, using handtools.
3. Connects fuel, oil, and water lines to engine.
4. Installs engine controls, propeller shaft, and propeller.
5. Attaches test instruments, such as tachometer and voltmeter to engine.
6. Starts engine and records operating data, such as revolutions per minute, and voltage output.
7. Disassembles defective engines and repairs or replaces damaged parts, using handtools.

JOB TITLE: Canvas Worker

D.O.T. No.: 739 381 010

Major Job Function:

Lays out canvas, plastic, rubber, and other materials and fabricates and assembles material into sails, awnings, tents and tarpaulins.

Job Duties:

1. Lays out full scale drawings on sail loft floor, according to blueprints or sketches, using chalk.
2. Cuts pattern from paper according to full scale drawing.
3. Marks outline on material with crayon.
4. Cuts material with shears or power cutter.
5. Sews sections of material together on power sewing machine.
6. Installs grommets, metal fittings, and fasteners by machine.
7. When hand-sewing grommets, measures and marks off grommet holes on material, punches holes, using mallet, punch, and hardwood block, and sews galvanized iron ring to edge of hole, using sailmaker's palm and sail twine.

JS WT 10

Canvas Worker Job Duties (continued):

8. Splices, inserts, and hems manila or wire rope in edges to relieve strain or sews rope at points where sail is attached to boom or mast.
9. Secures rope or cable to finished article.
10. Wraps and sews parts of rope or wire that are subject to chafing.
11. Installs and adjusts completed product on shipboard.
12. Examines completed sails for conformance to specifications.

JOB TITLE: Boat Rigger

D.O.T. No.: 806 464 010

Major Job Function:

Installs accessories in outboard or inboard motorboats.

Job Duties:

1. Drills holes, attaches brackets, and installs accessories, such as lights, batteries, ignition switches, fuel tanks, and guide pulleys, using handtools and power tools.
2. May change propellers and adjust motors to obtain maximum performance.
3. May install outboard and inboard motors and controls, using handtools.

JOB TITLE: Boat Outfitter

D.O.T. No.: 806 484 014

Major Job Function:

Installs parts, such as hatches, marine hardware, metal trim, seats, cabinets, and windshields on fiberglass, aluminum, or wooden boats, using handtools and portable power tools.

Boat Outfitter Job Duties:

1. Locates and marks position of hardware, seats, and other parts according to specifications, using rule, template, and marking device.
2. Cuts or grinds mounting bases or brackets, using portable electric saws and grinders, and bolts or screws them in place.
3. Drills holes and bolts hardware, hatches, and other parts in place, using handtools.
4. Applies caulking compound under spray rails, windshields, and around windows, using caulking gun.
5. Saws aluminum trim to specified lengths and cements, crimps, screws, or pounds trim into place, using hacksaw, crimping device, adhesives, screwdriver, and mallet.
6. Inspects completed boat for defects and writes report of appraisal.

JOB TITLE: Fiberglass Laminator

D.O.T. No.: 806 684 054

Major Job Function:

Laminates layers of fiberglass on molds to form boat decks and hulls.

Job Duties:

1. Selects precut fiberglass mat, cloth, and woodbracing materials, according to model number of boat.
2. Places layers of mat and cloth in mold and smooths out wrinkles by hand.
3. Trims excess material from mold, using hand shears.
4. Mixes catalyst into resin and saturates cloth and mat with mixture, using brush.
5. Works saturated mat and cloth into shape of mold with hands and squeegee, removing air bubbles and smoothing surface.
6. Bonds wood reinforcing strips to deck and cabin structures, using resin-saturated fiberglass.
7. Cuts hardened fiberglass from mold with trimming knife.

JS WT 12

JOB TITLE: Shipyard Laborer

D.O.T. No.: 809 687 022

Major Job Function:

Performs following tasks in shipyards.

Job Duties:

1. Loads vehicles, using handtruck or dolly.
2. Washes trucks and other vehicles.
3. Cleans ships, piers, drydocks, and other working areas, using broom and water hose.
4. Opens shipping crates, using hammer and pinchbar.
5. Sorts lumber, metals, and other scrap materials.
6. Collects and burns trash.
7. Mixes and pours cement on inner bottoms of ships and around joints on decks to prepare surfaces for tile or to make joints watertight.
8. Removes paint and scale from ship's metal surfaces, using hand or powered wire brushes.
9. Conveys materials and tools to worksite.

JOB TITLE: Wood Boatbuilder

D.O.T. No.: 860 381 018

Major Job Function:

Fabricates, repairs, or modifies wooden boas, liferafts, and pontoons, according to blueprints, using handtools, power tools, and measuring instruments.

Job Duties:

1. Lays out full-scale outline of boat on mold-loft floor, using crayon, scales, and protractor, following blueprints and table of offsets.
2. Establishes dimensional reference points on layout and makes templates.

Wood Boatbuilder Job Duties (continued):

3. Scribes dimensional lines on lumber, following templates.
4. Cuts and forms parts, such as keel, ribs, and sidings, using carpenter's handtools and power tools.
5. Assembles shell of boat by forming steam-softened sidings on mold, removing mold, and securing sidings to keel, or by securing ribs to keel and covering ribs with planking.
6. Builds and installs structures, such as pilot house, cabin, rubber, and foundations for machinery, shafting, and propeller supports, and installs preformed decking, masts, booms, and ladders, according to blueprints, using handtools, power tools, scale, calipers, and gauges.

JOB TITLE: Shipwright

D.O.T. No.: 860 381 058

Major Job Function:

Constructs or repairs ships, following blueprints or ship's plans.

Job Duties:

1. Sights, plots, and marks reference points and lines on building dock or shipway to maintain alignment of vessel during construction or repair, using transit, plumb bob, tapes and levels.
2. Builds keel and bilge blocks, cradles, and shoring for supporting ships in drydock, marine railways, shipways, or building docks, using woodworking handtools and power tools.
3. Positions and secures blocking and other structures on dock platform, according to ship's blueprints.
4. Aligns vessel over blocks.
5. Establishes reference points and lines on ship's hull for locating machinery and other equipment, in accordance with ship's alignment and shape.
6. Fabricates and installs furring pieces, aprons, uprights, and other wood framing in ship.
7. Shapes, finishes, and installs wooden spars, masts, and cargo and boat booms.

Shipwright Job Duties (continued):

8. Trims wooden frames and other timbers, using broadax and adz.
9. Spikes or bolts metal fittings, plates, and bulkheads to wooden parts of ship, using brace and bits, auger, mauls, and wrenches.

JOB TITLE: Dock Supervisor

D.O.T. No.: 891 131 010

Major Job Function:

Supervises and coordinates activities of workers engaged in drydocking, painting, cleaning, and repairing vessels.

Job Duties:

1. Analyzes vessel's blueprints and specifications to determine size, shape, and number of keel and bilge blocks required to support vessel.
2. Directs dock hand in assembling, positioning, and securing blocks to floating drydock platform, marine railway, or floor of graving dock.
3. Sights reference points for positioning vessel over blocks, using transit, and directs dock hand in aligning of vessel over blocks.
4. Directs workers in pumping operations to raise vessel and in positioning, flooding, and pumping caisson in graving dock.
5. Directs workers engaged in cleaning and maintenance of vessel.
6. Oversees flooding operations and removal of vessels from drydock.

JOB TITLE: Dock Hand

D.O.T. No.: 891 684 010

Major Job Function:

Performs following duties concerned with drydocking and cleaning exteriors of ships and maintenance of drydock and piers.

Dock Hand Job Duties:

1. Positions keel blocks on dock platform and builds bilge blocks as directed by dock supervisor, using handtools and clamps.
2. Opens flood valves in floating drydock sections to submerge platform.
3. Winds up docking lines using winch or snubs lines over dock cleats to position ship over drydock.
4. Starts pumps to remove water from drydock sections and turns pump controls to keep dock platform on even keel.
5. Washes or steam cleans exterior of ship's hull to remove marine growth and loose paint using high-pressure water hose or steam-cleaning equipment.
6. Scrapes barnacles or other marine growth from hull with long-handled scraper and chips rust or paint from hull with pneumatic tool.
7. Erects stages and scaffolds to reach sections of hull.
8. Opens and closes flood valves on drydock when removing ship from dock to keep dock platform on even keel as it submerges.
9. Floods or drains caisson of graving drydock and assists in floating caisson in or out of position across drydock entrance.

JOB TITLE: Barge Captain

D.O.T. No.: 911 137 010

Major Job Function:

Supervises and coordinates activities of workers on towed barge that transports cargo on lakes, bays, sounds and rivers.

Job Duties:

1. Directs workers engaged in loading and unloading barge to insure that cargo is loaded according to balancing specifications.
2. Inspects barge to insure that craft is seaworthy.
3. Signals tugboat captain to tow barge to destination.

JS WT 16

Barge Captain Job Duties (continued):

4. Logs barge's movements and ports-of-call.
5. Steers barge when it has steering equipment.

JOB TITLE: Ferryboat Operator

D.O.T. No.: 911 363 010

Major Job Function:

Operates power ferryboat to transport passengers, motor vehicles, and freight across rivers.

Job Duties:

1. Signals passengers to board ferryboat and directs loading of motor vehicles and freight.
2. Signals deckhand to raise loading ramp and to pull guard chain across entry.
3. Starts engine to move ferryboat to opposite side of body of water.
4. Collects fares from customers or signals ferryboat operator helper to collect fares.
5. Determines course and speed of ferryboat utilizing knowledge of weather conditions and water currents.
6. Reverses engines and steers boat into landing pier.
7. Inspects, lubricates and performs emergency repairs to railings, pontoons and winches to insure safe operation of ferry.

JOB TITLE: Quartermaster

D.O.T. No.: 911 363 014

Major Job Function:

Steers ship and maintains visual communications with other ship.

Quartermaster Job Duties:

1. Steers ship under direction of ship's commander or navigating officer or directs helmsman to steer following designated course.
2. Stands by wheel when ship is on automatic pilot and verifies accuracy of course by comparing with magnetic compass.
3. Relays specified signals to ships in vicinity using visual signalling devices such as bunser light and semaphore.
4. Gives directions to crew engaged in cleaning wheelhouse and quarter deck.
5. Maintains ship's log while in port and stands gangway watch to prevent unauthorized persons from boarding ship.

JOB TITLE: Deckhand

D.O.T. No.: 911 687 022

Major Job Function:

Performs any combination of following duties aboard watercraft, such as dredges, ferryboats, scows and riverboats.

Job Duties:

1. Handles lines to moor vessel to wharves, tie up vessel to another vessel or rig towing lines.
2. Sweeps and washes decks using broom, brushes, mops and fire-hose.
3. Lowers and mans lifeboat in case of emergencies.
4. Stands steering watches or lookout watches while underway.
5. Moves controls or turns handwheels to raise or lower passenger or vehicle landing ramps or kelp-cutter mechanism.
6. Inserts blocks under wheels of vehicles to prevent them from moving on ferryboats.
7. Loads or unloads material from barges, scows and dredges.
8. Paints lifeboats, decks, and superstructure of vessel using brush.

JS WT 18

Deckhand Job Duties (continued):

9. Lubricates machinery and equipment.
10. Splices and repairs cables and ropes using handtools.
11. Examines cables that holds vessels in tow and tightens cables to insure vessels are snug.

JOB TITLE: Seaman

D.O.T. No.: 911 687 030

Major Job Function:

Stands deck department watches and performs a variety of duties to preserve painted surfaces of ship and to maintain operating condition.

Job Duties:

1. Watches from bow of ship or wing of bridge for obstructions in path of ship.
2. Turns wheel while observing compass to steer and maintain ship on course.
3. Mops or washes down deck using hose to remove oil, dirt and debris.
4. Chips and cleans rust spots from deck, superstructure and sides of ship using hand or air chipping hammer and wire brush.
5. Paints chipped area.
6. Splices wire rop using marlinspike, wirecutters and twine.

JOB TITLE: Tower-Loader Operator

D.O.T. No.: 921 683 074

Major Job Function:

Operates mechanical loading tower to load ships and barges with raw materials such as coal, iron ore or iron pellets.

Tower-Loader Operator Job Duties:

1. Moves controls, levers and presses pedals to position tower for loading operations to lower conveyer directly over vessel hatch and to position chute to guide materials into hold of ship.
2. Starts conveyor belt to convey materials from stockpile or gondola cars into hold of vessel.
3. Moves chute controls to spread materials evenly throughout hold of vessel.
4. Adjusts and makes minor repairs to tower and accessory equipment.

JOB TITLE: Stevedore

D.O.T. No.: 922 687 090

Major Job Function:

Loads and unloads ship' cargoes.

Job Duties:

1. Carries or moves cargo by handtruck to wharf and stacks cargo on pallets or cargo boards to facilitate transfer to and from ship.
2. Stacks cargo in transit shed or in hold of ship as directed by header.
3. Attaches and moves slings used to lift cargo.
4. Guides load being lifted to prevent swinging.
5. Shores cargo in ship's hold to prevent shifting during voyage.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

PRIME MOVERS

Title of Unit:

HEAT ENGINES

DESCRIPTION OF UNIT

This unit will explain the basic nature and function of heat engines in general. The concept of using a chemical fuel to produce thermal energy which is converted into mechanical energy is covered. The four basic types of engine cycles is covered and their use and application is included so that students will have an overall idea as to their place in the area of transportation. Internal and external combustion engines will be covered. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to: identify terms related to heat engines, list the four basic types of engine cycles, identify the prime application of different types of heat engines, and, explain the differences between internal and external combustion engines.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Match a list of terms with their correct definitions.
2. List and describe the four basic type of engine cycles.
3. List at least one application of each of the basic engine cycles. Explain how it relates to transportation.
4. Identify the four strokes and 5 events in an Otto cycle engine.
5. Identify the five events of the Brayton cycle engine.

PM 1.2

6. Identify the 4 events of the Stirling cycle engine.
7. Identify the 4 events of the Rankine cycle engine.
8. Explain the difference between the internal combustion engine and the external combustion engine.

OUTLINE OF CONTENT

Heat Engines

Any device which uses heat to produce mechanical energy. Usually a chemical fuel which is burned to produce thermal energy which in turn is converted into mechanical (movement) energy or motion.

I. Internal Combustion Heat Engines

Any of a wide range of engines which burns a chemical fuel inside the engine proper and which directly applies this thermal or heat energy to the engine to convert heat energy into mechanical energy.

A. Otto Cycle Engine

Any of a great number of engines which employs five definite events which occur one after the other in a definite sequence and are of the internal combustion type engines. The Otto cycle engine may be divided into two groups or four subgroups. The two groups are:

1. Spark ignition Otto cycle engine
 - a. 2-stroke cycle engines
 - b. 4-stroke cycle engines
2. Compression ignition Otto cycle engine
 - a. 2-stroke cycle engines
 - b. 4-stroke cycle engines

B. The Spark Ignition Otto Cycle Engine

The spark ignition is the method of starting the initial combustion flame which burns the fuel. The spark may be produced in several ways but generally is introduced into the combustion chamber of the engine by a spark plug. The spark plug has a gap between the high tension lead and the ground across which a spark is made to jump, creating a very hot spark (4000°F or more). This spark causes the fuel and air to ignite and burn.

C. The 2-stroke Otto cycle spark ignition engine

The 2-stroke cycle engine is often called simply a 2-cycle engine. This engine completes all five events in two strokes. One down stroke and one up stroke or one revolution to complete one cycle.

1. The five events are:

- a. Intake--Fuel and air are taken into the combustion chamber.
- b. Compression--Fuel and air are compressed in the engine.
- c. Ignition--Spark ignites the fuel and air mixture.
- d. Power--Fuel and air are burned causing temperature and pressure to increase greatly. This pushes the piston or moving part which is the mechanical energy.
- e. Exhaust--When the fuel and air are burned, the remaining waste heat and gases are expelled from the cylinder.

2. Application in Transportation:

The 2-stroke cycle spark ignition engine is used to power many types of devices including:

- a. Chain saws--Most chain saws use 2-stroke cycle engines.
- b. Outboard engines--Most outboard engines are of the 2-stroke cycle type.
- c. Motorcycle--Many motorcycles use 2-stroke cycle engines.
- d. Automobiles--A small number of automobiles use 2-stroke cycle engines.
- e. Aircraft--Very few aircraft use 2-stroke cycle engines except model planes.
- f. Lawn mowers, etc.--Many other uses from drills to go-carts and snowmobiles use 2-stroke cycle engines.

D. The 4-stroke cycle spark ignition Otto cycle engines

The 4-stroke cycle engines require the same five events as the 2-stroke cycle engines but accomplish the five events in four strokes: two up strokes and two down strokes. This requires two complete revolutions of the engine to complete one full cycle.

1. The five events are:

- a. Intake--Down stroke draws fuel and air in.
- b. Compression--Up stroke compresses fuel and air.
- c. Ignition--Spark occurs near top of stroke.
- d. Power--Down stroke. Expanding gases push down.
- e. Exhaust--Up stroke. Burned gases are expelled.

2. Application in Transportation:

- a. Automobiles--Most automobiles use 4-stroke cycle Otto engines.
- b. Aircraft--Usually called "piston engine planes". Used by non-jet aircraft and most small planes.
- c. Ships--Some ships and outboards and many small pleasure cruisers use inboard 4-stroke cycle engines.
- d. Lawnmowers and etc.--The application of 4-stroke cycle engines covers many fields of transportation from pumps to helicopters.

E. The compression ignition Otto cycle engine

The compression ignition engine does not rely on a spark to ignite the fuel. This type of engine is often called a diesel engine because of its original inventor, Rudolph Diesel. The principle of operation is that the air in the engine is compressed to a great degree (14 to 1 compression ratio or higher) which causes the temperature of the air to be increased. At this high compression, high temperature, the fuel is sprayed into the combustion chamber or cylinder which is above the flash point of the fuel. The fuel then ignites without a spark and fumes to produce the heat energy.

F. The 2-stroke cycle compression ignition Otto cycle engine

The 2-stroke cycle compression engines have the same five events but uses the heat of compression rather than the spark to ignite the fuel and air. The five events require two strokes: one down stroke and one up stroke. This is one complete revolution of the engine. The compression ignition engine also requires one other part of the engine in addition to the regular parts of a 2-stroke cycle spark ignition engine. That is the blower or compressor. This is a device which compresses outside air before it enters the cylinder. This enables the compression ignition 2-stroke cycle engine to remove more of the burned gases and also to have an oil base or sump for lubricating oil.

1. The five events are:

- a. Intake--Air is forced into the cylinder by the blower at the bottom of the down stroke.
- b. Exhaust--The burned fuel and air mixture is forced out of a valve which opens in the top of cylinder while the piston is at the bottom of the down stroke.
- c. Compression--The air is compressed when the piston moves up on the up stroke and the intake part and exhaust valve are closed.

- d. Ignition--Ignition occurs at the top of the upstroke when the fuel is injected or sprayed into the hot air under pressure.
- e. Power--The power stroke occurs as the fuel and air burn on the downstroke.

2. Application in Transportation:

- a. Vehicles--Some trucks and cars use 2 stroke cycle diesel engines.
- b. Ships--Small ship and fishing vessels employ many 2-stroke cycle diesels because of their light weight as compared to 4-stroke cycle diesels.
- c. Aircraft--Very few aircraft use any type of diesel engines because of their power to weight ratio.
- d. Other applications--Most other applications are for pumps to transport fluid and for emergency generators or emergency applications.

G. The 4-stroke compression ignition Otto cycle engine

The 4-stroke compression ignition engine is most frequently referred to as a "diesel". This means the five events require four strokes or two complete revolutions to accomplish the one complete cycle.

1. The five events are:

- a. Intake--Air is drawn into the cylinder on the down stroke.
- b. Compression--Air is compressed (14 to 1 up to 27 to 1; usually about 22 to 1).
- c. Ignition--Ignition occurs when the fuel is sprayed through an injector into the very hot air under high pressure.
- d. Power--The burning fuel and air expand at high temperature and pressure which forces the piston down the cylinder developing mechanical power.
- e. Exhaust--The piston moves up the cylinder forcing the burned gases out of the exhaust valve.

2. Application to Transportation:

- a. Vehicles--The greatest number of diesel engines are used in transportation. These include trucks of all kinds. Most heavy trucks use diesel engines.
- b. Trains--Nearly all of the modern train engines or locomotives use diesel engines. (These are often called diesel electric because the diesel engine drives generators which then drive electric motors. This system is used because the great power of the engines would require very large and expensive clutches to transmit the power smoothly and evenly.)
- c. Ships--Many large ships and tugs use diesel engines. Some submarines and warships use diesels.
- d. Aircraft--Very few aircraft have ever used diesels. Weight is a most important factor.
- e. Automobiles--More and more automobiles now use diesels. The primary reason is their efficiency. They are more efficient than spark ignition engines as a whole.

H. Brayton Cycle Engines

Brayton cycle engines are internal combustion type engines which have five events. These events occur in different sections of the engine and each event occurs all of the time rather than in a sequence like the Otto cycle. There are two major groups of Brayton cycle engines: jet engines and turbine engines. The engines function in almost identical ways but the major difference is in the method of deriving mechanical power from the engines.

1. Jet engines--The jet engine is a Brayton cycle engine which derives its name from the fact that the chemical fuel is burned inside the engine and produces a high speed jet of exhaust gases which are expelled out of the engine in a controlled direction and velocity. There are three classes of jet engines:
 - a. Pulsejets--These engines take in air through an opening which has a shutter or reed which closes when the fuel is ignited and pressure builds up in the engine. This engine is not very practical because of its very low efficiency and extreme noise. The pulsejet has four events which occur. These are:
 - (1) Intake--Air is forced into the diffuser section which converts high speed low pressure air into low speed high pressure air.

- (2) Ignition--A spark type ignition system is used. The chief difference is that the spark is a continuous spark until the engine is running.
- (3) Combustion--The fuel air mixture burns rapidly and the exhaust gases rush out the tail section.
- (4) Exhaust--Partial vacuum created by rapid drop in pressure near the end of the combustion period draws fresh air through diffuser and fuel is injected. Flame from burning gases is drawn back up the tail-pipe and reignites without a spark.
- (5) Application to transportation:

Little commercial use is made of the pulsejet because of its very poor efficiency and terrific noise. Some model planes, boats and race vehicles use pulsejets.

b. Ramjets

These are the simplest type of jet engines. They are sometimes called "flying stovepipes". This name comes from the fact that there are no moving parts of the engine. The technical name is aerothermodynamic ductor, ATHODYD, for short. This Brayton cycle engine cannot operate if it is not moving. The air must be forced or rammed into the front or diffuser section. The fuel is sprayed into the combustion section and ignited by a spark plug. The burning gases pass through a flame holder which holds the flame in the rear of the combustion chamber. There are four events which occur in the ramjet engine:

- (1) Ram intake--Air is forced into the front opening or diffuser section of the engine.
- (2) Ignition--Fuel and air mixture is ignited in combustion chamber by spark and then burns continuously.
- (3) Combustion--The fuel and air burns continuously. The flame holder prevents the flame from moving completely out of the tail section.
- (4) Exhaust--The high speed high temperature gases exhaust out of the tail section.

(5) Application to transportation:

The application of ramjet engines is severely limited because of the two major drawbacks. The engine must be moving some 200 mph before it will sustain firing (a). The engine requires enormous fuel supplies (b).

- (a) Aircraft--The chief use of the ramjet is its application in high speed aircraft interceptors and missiles.
- (b) Helicopter--Some helicopters use small ram jets mounted on the rotor tips. These engines are supplied with fuel which is channeled through the rotors and ignited when the rotor is turned to the starting speed by a starter motor.

2. Turbojet engines

The turbojet engines are the most common Brayton cycle engines and fall into two groups.

- a. Centrifugal turbojets--This type of engine takes the air into the center of the engine and throws the air out through a series of centrifugal fans to compress the air.
- b. Axial flow turbojet engine--This type of engine uses a series of rotor and stator blades to force the air along the inside of the engine to the combustion section. There are five major events which occur all of the time in the turbojet engine. These four events are:
 - (1) Intake--Air is drawn into the engine by the spinning compressor section.
 - (2) Compression--The air is compressed to high pressure by the compressor.
 - (3) Ignition--Ignition is started by spark plugs in the combustion section.
 - (4) Combustion--The fuel and air is burned in the combustion section or burner tubes. The tubes are connected by a series of flame tubes which keeps the fuel and air burning.
 - (5) Exhaust--The burning fuel and air exhaust through a turbine wheel which spins and drives the compressor.

(6) Applications to transportation:

(a) Aircraft--The chief use of turbojet engines is to power aircraft of a wide range. Military aircraft includes fighter aircraft: bombers, surveillance aircraft and transport planes. Civilian aircraft includes: most commercial airliners, cargo planes and small executive jets.

(b) Ships--Some hover craft.

II. External Combustion Heat Engines

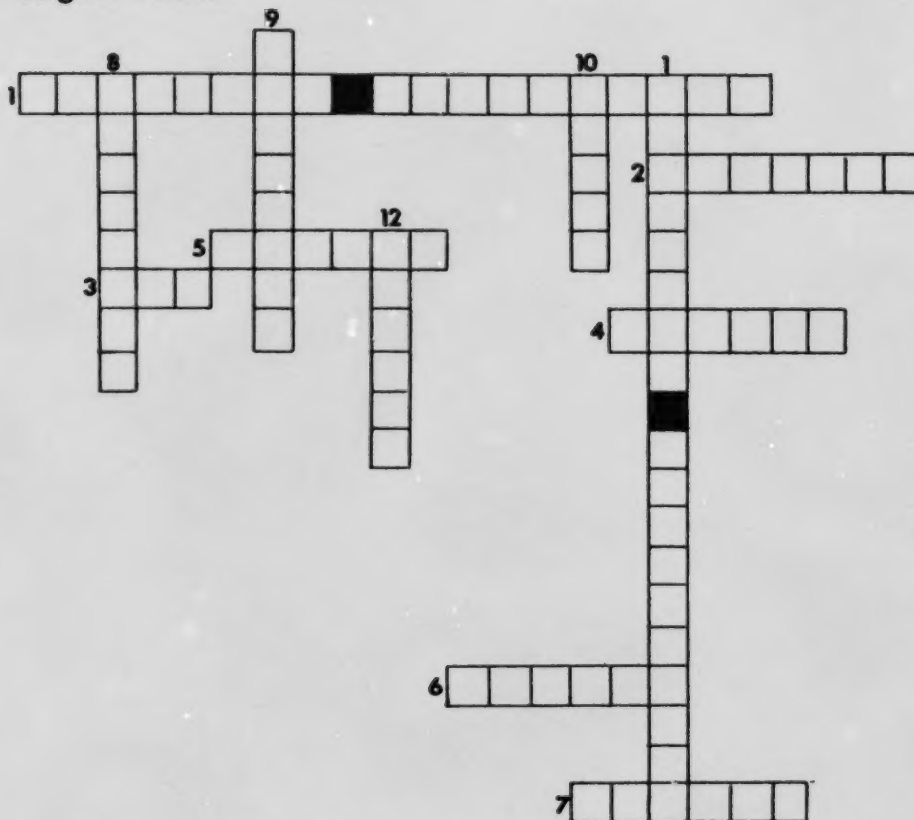
Information Sheet #1

Terms and Definitions

1. Steam engine--Reciprocating external combustion engine.
2. Steam turbine--Non-reciprocating external combustion engine.
3. Gasoline engine--A four-cycle internal combustion engine requiring spark plugs.
4. Ramjet--A jet with no moving parts.
5. Turbojet--An engine with a turbine driven air compressor used in most high-speed aircraft.
6. Fanjet--A jet engine in which some air bypasses the combustion chamber.
7. Rocket engine--Only engine that will operate in the vacuum of space.
8. Diesel engine--Internal combustion engine which requires no spark plugs.
9. Turbine--An engine turned by the force of a gas or liquid acting against its vanes or blades.
10. Jet engine--Engine that gets thrust from high speed exhaust gases.
11. Engine--A machine that changes another form of energy into mechanical energy.
12. Reciprocating engine--Engine which converts heat energy to mechanical energy by the back and forth motion of a piston in a cylinder.
13. Wankel rotary engine--A small gasoline engine that does not use pistons.
14. External combustion engine--The kind of engine in which the fuel is burned outside the engine.
15. Internal combustion engine--The kind of engine in which the fuel is burned inside the engine.

Student Activity #1

Engine Puzzle

Across

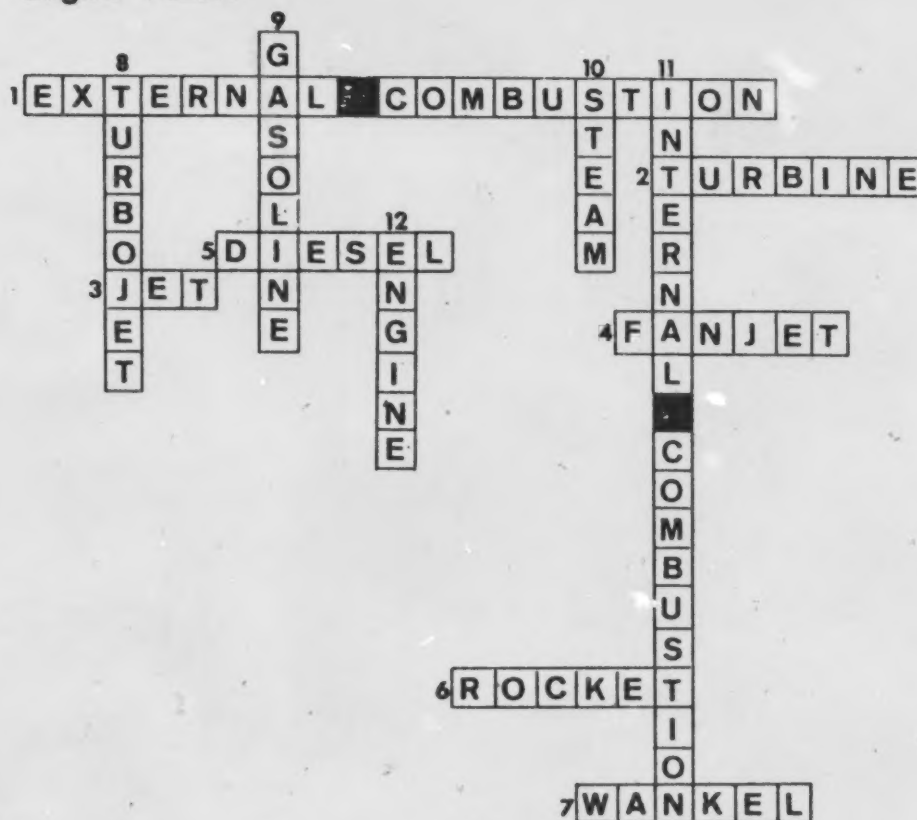
1. The kind of engine in which fuel is burned outside the engine.
2. This engine is turned by the force of a gas or liquid acting against its vanes (blades).
3. The engine that gets thrust from high speed exhaust gases.
4. A jet in which some air by-passes the combustion chamber.
5. An internal combustion engine which requires no spark plug.
6. The only engine that will operate in a vacuum.
7. A small gasoline engine that does not use pistons.

Down

8. An engine with an air compressor used in most high speed aircraft.
9. A four-cycle internal combustion engine requiring spark plugs.
10. Non-reciprocating external combustion engine.
11. The kind of machine in which fuel is burned inside the engine.
12. A machine that changes another form of energy into mechanical energy.

ANSWERS TO STUDENT ACTIVITY #1

Engine Puzzle

Across

1. The kind of engine in which fuel is burned outside the engine.
2. This engine is turned by the force of a gas or liquid acting against its vanes (blades).
3. The engine that gets thrust from high speed exhaust gases.
4. A jet in which some air by-passes the combustion chamber.
5. An internal combustion engine which requires no spark plug.
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8. An engine with an air compressor used in most high speed aircraft.
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11. The kind of machine in which fuel is burned inside the engine.
12. A machine that changes another form of energy into mechanical energy.

SUGGESTED PRE/POST TEST

True or False (Circle correct answer)

- T F 1. Jets and rockets are usually internal combustion heat engines that belong to a class of engines known as reaction engines.
- T F 2. The principle on which these engines is based is known as Newton's 3rd law of motion.
- T F 3. One of the first demonstrated engines of this type was designed and built before Christ. It was Nero's.
- T F 4. Jet engines are air independent engines.
- T F 5. Rocket engines are air dependent engines.
- T F 6. The Father of modern rockets is Dr. Robert Goddard.
- T F 7. The two major classifications of rockets are liquid fuel rockets and solid fuel rockets.
- T F 8. The single most powerful rocket ever developed was the Saturn V booster and it had a combined thrust of 7,500,000 pounds.
- T F 9. Hydrogen peroxide is used as a rocket propellant.
- T F 10. Solid rocket propellant is referred to as a "grain".
- T F 11. Black powder was one of the first solid propellant rocket fuels.
- T F 12. There are at least 4 types of gas turbine engines.
- T F 13. The steam engine is a "heat engine".
- T F 14. Water expands into steam at the rate of 160 to 1 ratio.
- T F 15. The "Newcome" engine pumped water by normal air pressure.
- T F 16. The two major factors in increased steam engine efficiency are (1) higher steam pressure, and (2) higher engine speed.
- T F 17. The most widely used turbine today is the reaction turbine.
- T F 18. Most of the turbines of today derive power both from the reaction and impulse principle.
- T F 19. The diesel engine is a compression ignition engine.
- T F 20. The principle of the diesel engine is used to start fires by the natives of the South Pacific.

- T F 21. The inventor of the diesel engine was Dr. Rudolph Diesel.
- T F 22. The first successful diesel engine was built in 1897.
- T F 23. The fuel injector replaces the spark plug in the diesel.
- T F 24. The tolerance of the fuel injector is accurate within a range of 30 to 60 thousandths of an inch.
- T F 25. There are five basic simple machines.
- T F 26. The propeller of a boat engine is an example of the inclined plane.
- T F 27. The future use of nuclear power depends upon the use of "breeder reactors".
- T F 28. Three types of carburetors are used on small engines.
- T F 29. Both engine position and fin position are used to control attitude and direction of rockets in flight.

Multiple Choice (Place letter of correct answer in space provided)

- _____ 30. The weight of an object depends upon its
- a. mass and volume
 - b. mass and size
 - c. mass and density
 - d. mass and position
 - e. mass and viscosity
- _____ 31. The following is not a unit of measurement in the metric system.
- a. centimeter
 - b. gram
 - c. second
 - d. rod
 - e. kilogram
- _____ 32. Should you convert 40° C to Fahrenheit you would get
- a. 80.0° F
 - b. 104.0° F
 - c. 212.0° F
 - d. 410.0° F
 - e. 20.0° F
- _____ 33. The quantity of a gallon of liquid
- a. is the same world wide
 - b. is smaller in the U.S. than in other countries
 - c. is greater in the U.S. than in other countries
 - d. varies according to the shape of the container
 - e. cannot be answered

- _____ 34. The venturi is a commonly used device relating to
- a. Pascal's law
 - b. Boyle's law
 - c. Bernoulli's law
 - d. Charles law
 - e. none of these
- _____ 35. Hydraulic is the branch of fluid power which deals with
- a. jacks
 - b. oil
 - c. liquid
 - d. brakes
 - e. transmission
- _____ 36. The hydraulic fluid is pushed through the system by the
- a. prime mover
 - b. reservoir
- _____ 37. Which of the following is true for steam as it passes through a steam turbine?
- a. pressure increases and speed increases
 - b. pressure decreases and speed increases
 - c. pressure increases and speed decreases
 - d. pressure decreases and speed decreases
- _____ 38. Which of the following is not a component of solid propellant rocket fuel?
- a. nitroglycerine
 - b. nitrocellulose
 - c. potassium perchlorate
 - d. sodium bicarbonate
- _____ 39. Which of the following is not a basic type of jet engine
- a. turbo
 - b. pulse
 - c. thrust
 - d. ram
- _____ 40. Which of the following is not one of the countries most important in the initial development of jet engines?
- a. U.S.A.
 - b. England
 - c. Russia

- _____ 41. Which of the following is not characteristic of diesel engine
- a. high RPM
 - b. high compression
 - c. high weight
 - d. high efficiency
- _____ 42. The reed valves on small engines are designed to do all the following except
- a. open when the piston travels up the cylinder
 - b. prevent the fuel-air mixture from entering the engine
 - c. close on the power stroke
 - d. open on the compression stroke
 - e. prevent the fuel-air mixture from escaping from the engine.
- _____ 43. Which of the following is not a stroke of the reciprocating engine?
- a. intake
 - b. compression
 - c. power
 - d. purge
 - e. exhaust
- _____ 44. The "rings" in an engine do all the following except
- a. prevent oil usage
 - b. increase compression
 - c. prevent knock
 - d. increase power
- _____ 45. Which of the following has the least effect on engine speed?
- a. fuel
 - b. governor
 - c. throttle
 - d. plugs
 - e. points
- _____ 46. Which of the following is not a part of the magneto ignition system
- a. magnet
 - b. condenser
 - c. points
 - d. battery
 - e. coil
- _____ 47. The lobe of a cam is shaped like
- a. a gear
 - b. a circle
 - c. an egg
 - d. a mushroom
 - e. Karl Malden's nose

_____ 48. Which of the following is not a stroke of the internal combustion engine

- a. compression
- b. ignition
- c. power
- d. exhaust
- e. intake

TENNESSEE INDUSTRIAL ARTS CURRICULUM

Instructional Section:

PRIME MOVERS

Title of Unit:

OTTO CYCLE INTERNAL COMBUSTION ENGINES

DESCRIPTION OF UNIT

This unit will cover internal combustion engines which belongs to the Otto cycle class. The unit will give an overview of both two-stroke cycle engines and four-stroke cycle engines. The basic parts of an engine will be covered as well as the materials of construction. The unit will cover the internal combustion engine as a prime mover. The place of the internal combustion Otto cycle engine in the field of transportation will be stressed. This unit requires approximately 20 hours to complete.

UNIT OBJECTIVE

Upon the completion of this unit the student will be able to define an engine and give the basic theory of operation of an internal combustion heat engine. The student will be able to describe in detail the Otto cycle internal combustion engine operation. The student will be able to explain compression ratio and displacement. The student will be able to disassemble and reassemble a small engine such as a lawn mower engine. The student will be able to explain the importance of the Otto cycle engine as one of the most important of the internal combustion engines in the area of transportation.

PERFORMANCE OBJECTIVES

Upon completion of this unit the student will:

1. Match given terms with correct definitions.
2. Define the term "internal combustion engine".
3. Define a prime mover.
4. List and describe the "Otto Cycle" internal combustion cycles.

PM 2.2

5. Make four sketches showing the four strokes of a four-stroke cycle engine.
6. Make four sketches showing the two strokes of a two-stroke cycle engine.
7. The student will list and describe five occupations related to transportation.
8. The student will demonstrate knowledge of a small engine by disassembly and reassembly as instructed.
9. The student will be able to orally or in writing describe a diesel engine.
10. The student will be able to orally or in writing describe the principle of a carburetor.
11. The student will be able to demonstrate the basic principle of the spark ignition system of a magneto and of a high tension coil.

OUTLINE OF CONTENT

I. Construction

How the engine is made.

- A. Materials--The metals and other materials used in the construction of engines. Cast iron, aluminum, steel.
- B. Components--Engine block or base, cylinder, cylinder head, piston, crankshaft, connecting rod, valves, cam.
- C. Arrangement of cylinders--Cylinders may be arranged in rows, banks, V's, inline.

II. Fuel System

Components and adjustments.

- A. Carburetor--The device which meters fuel and air into the engine combustion chamber.
- B. Fuel systems--Gravity flow, fuel pump or suction.
- C. Governors--Air vane (pneumatic) or fly weight (mechanical) device which keeps engine at constant speed.

III. Lubrication

Bearings and oil.

- A. Bearings--(Friction/Anti-friction) Friction bearings, bushing or inserts, anti-friction needle or ball.
- B. Oil--(Type and designation) Weight, service recommendation and viscosity properties of oil.
- C. Oil additives--Anti-foaming, detergent, anti-corrosion.
- D. Systems--Dip.
- E. Breather--Vent to engine base, partial (2 lbs) vacuum to base of engine.

IV. Cooling System

How engine heat is removed.

- A. Air cooled engines--Heat removed by conduction (metal), convection (air), radiation.
- B. Liquid cooled engines--Radiator, coolant pump, fluid--water and antifreeze.

- C. Heat transfer within the engine--(Conduction) Metal heat travels from hot area to cold area.

V. Ignition

Types of ignition systems.

- A. Compression ignition--(diesel) Compressed air is heated to flash point of fuel; fuel sprayed into cylinder.
- B. Spark ignition
- C. Magneto spark--High tension spark which ignites fuel-air mixture in engine.
- D. High tension coil--Transformer like device which increases low voltage to high voltage.
- E. Spark plugs--Device in engine which has gap across which spark jumps.

VI. Prime Movers

Definition & Examples

- A. Prime movers defined--A prime mover is any device or machine which is used to convert potential energy into kinetic energy.
- B. Example: 1. Otto cycle engines. Automobile engines.
- C. Example: 2. Brayton cycle engines. Jet engines.
- D. Example: 3. Stirling cycle engines. Freon engines.
- E. Example: 4. Rankine cycle engines. Steam engines.

TEACHER ACTIVITIES

1. Prepare definition sheet of selected relevant terminology.
2. Prepare transparencies for illustration of basic concepts in Otto-cycle engines. Two-stroke cycles and four-stroke cycle.
3. Obtain slide presentation on maintenance and repair of small engines. (Briggs and Stratton Company)
4. Gather required equipment/supplies for students to disassemble and reassemble small engine.
5. Secure fuel and oil in T.O.S.H.A. approved containers.
6. Prepare a cutaway of a two-stroke and four-stroke engine showing major components.
7. Prepare transparencies of diesel engine.

STUDENT ACTIVITIES

1. Study terminology sheet and transparency material.
2. Closely observe slide presentation on maintenance and repair.
3. Disassemble and correctly reassemble a small engine.
4. Draw four sketches showing the four strokes of a 4-stroke cycle engine.
5. Draw four sketches showing the two strokes of a 2-stroke cycle engine.
6. Take notes from slide presentation for later reference in disassembly and reassembly of small engine.

REFERENCES/RESOURCES

References:

1. Bohn, Ralph C. and Angus MacDonald, Power: Mechanics of Energy Control, Bloomington, Ill.: McKnight & McKnight Publishing Company, 1970.
2. Drake, George R., The Repair and Maintenance of Small Gasoline Engines, Reston, Va.: Reston Publishing Co., 1976.
3. Geil, John J., and Stephen Johnson, Energy and Transportation: Industry and Careers, Englewood Cliffs, New Jersey, Prentice-Hall Inc., 1976.
4. Roth, Alfred C., Small Gas Engines, South Holland, Ill.: Goodheart-Wilcox Company, 1975.
5. Stephenson, George E., Power Technology, Albany, New York: Delmar Publishers, 1973.
6. Walker, John R., Exploring Power Technology, South Holland, Ill.: Goodheart-Wilcox Company, 1976.
7. Worthington, Robert M., Morton Margules and William Crouse, General Power Mechanics, New York: McGraw-Hill Book Company, 1968.
8. Yadon, James N., Energy & Transportation: Small Engines, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

Resources:

1. Transparencies on engine design
2. Terminology sheet
3. Slide presentation (Briggs & Stratton)
4. Small 2-stroke internal combustion engine
5. Small 4-stroke internal combustion engine
6. Cut-away engine model (teacher or student-made).

Terms and Definitions

1. Anti-friction bearing--Needle or roller type bearing.
2. Bearing--Parts of an engine or machine which separate or support moving parts from other parts to prevent heat and wear.
3. Cam--Lobe or eccentric which opens and closes valve or move plunger, as cam shaft.
4. Carburetor--The device which meters the fuel, air ratio or mix which is burned in the engine.
5. Coil--A coil of wire such as copper which increases the strength of a magnetic field.
6. Compression--The pressure in the cylinder as the piston moves toward the cylinder head and squeezes the air into a small space.
7. Compression ratio--The space at the top of the cylinder when the piston is all the way up compared to the space when the piston is all the way down the cylinder.
8. Condenser--Capacitor, electron storage device, part of ignition system.
9. Cylinder--Very smooth cylinder in which the piston moves back and forth and in which combustion takes place.
10. Cylinder head--The top or cover which encloses one end of the cylinder; usually the spark plug is screwed into the head.
11. Diesel--Compression ignition or burning caused by heat from air being compressed. Named for Dr. Rudolph Diesel as a diesel engine.
12. Displacement--The space in the cylinder displaced by the piston in its up and down movement as CID (cubic inch displacement) or cc (cubic centimeter).
13. Lubrication--The fluid, usually oil, which flows around parts of the engine to separate moving parts and prevent friction and heat.
14. Magneto--A device which produces an electric spark or flow of electrons by passing a conductor through a permanent magnetic field.
15. Spark--The spark or flow of electrons across a gap such as the gap of a spark plug to ignite fuel.
16. Timing--The procedure of placing the valves and spark so that they work in the proper sequence or time.

Small Gas Engines

The following chart lists the differences between two- and four-cycle engines.

CHARACTERISTICS	FOUR CYCLE ENGINE (equal hp) ONE CYLINDER	TWO CYCLE ENGINE (equal hp) ONE CYLINDER
1. Number of major moving parts	Nine	Three
2. Power strokes	One every two revolutions of crankshaft	One every revolution of crankshaft
3. Running temperature	Cooler running	Hotter running
4. Overall engine size	Larger	Smaller
5. Engine weight	Heavier construction	Lighter in weight
6. Bore size equal hp	Larger	Smaller
7. Fuel and oil	No mixture required	Must be pre-mixed
8. Fuel consumption	Fewer gallons per hr.	More gallons/hour
9. Oil consumption	Oil recirculates and stays in engine	Oil is burned with fuel
10. Sound	Generally quiet	Louder in operation
11. Operation	Smoother	More erratic
12. Acceleration	Slower	Very quick
13. General maintenance	Greater	Less
14. Initial cost	Greater	Less
15. Versatility of operation	Limited slope operation (Receives less lubrication when tilted)	Lubrication not affected at any angle of operation
16. General operating efficiency (hp wt. ratio)	Less efficient	More efficient
17. Pull starting	Two crankshaft rotations required to produce one ignition phase	One revolution produces an ignition phase
18. Flywheel	Requires heavier flywheel to carry engine through 3 non-power strokes	Lighter flywheel

OTTO CYCLE

Slide series

Briggs & Stratton

Air Cooled Engine Repair Program

Dis-Assembly Inspection and

Re-Assembly Procedures

Briggs & Stratton Corporation
Milwaukee, Wisconsin

DIESEL ENGINES

For centuries, the natives of the South Pacific have employed an ingenious method for lighting fires. Using a bamboo cylinder in which dry tinder is placed, a close-fitting plug is driven sharply into the open end. The air entrapped in the cylinder is compressed and heated to the point where the tinder ignites. This spontaneous combustion from the heat of compression is the principle of compression ignition, the basis on which the diesel engine operates.

The characteristic, then, of the diesel engine which distinguishes it from other internal combustion engines is the absence of any external ignition device. The gasoline engine uses an outside spark source to ignite the fuel mixture. This type of engine is thus known as a spark-ignition engine. The diesel, however, uses only the terrific heat generated by the compression of air in the cylinder to ignite the fuel. Thus, the diesel is a compression-ignition engine.

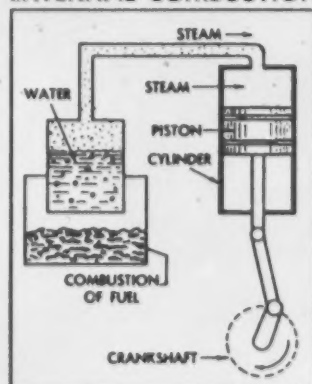
The inventor of the diesel engine, Dr. Rudolph Diesel, was born in 1858 of German parents. He became interested in engines during his college years. He was graduated as an engineer when he was 21 years old and he immediately set out to build an engine that

would be more efficient than the low efficiency steam engines of the time. His first engine was patented in 1892. But when built, it exploded as he tried to start it. However, he escaped serious injury in the unfortunate explosion. The tragedy did not cause him to give up; he was further convinced of the correctness of his basic ideas. A few years later, 1897, Dr. Diesel did produce a successful engine, a single-cylinder engine capable of developing 25 hp.

The first commercial diesel engine was put into service a year later in St. Louis, Mo. It was a two-cylinder, 60-horsepower engine. The use of diesel engines spread rapidly and, in a few years, thousands of engines were in use.

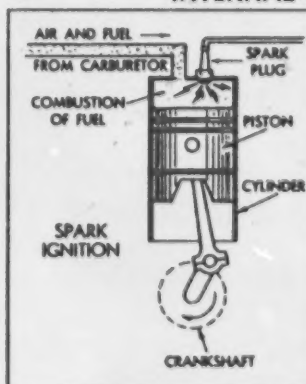
The early engines were used mostly to replace steam engines in large installations such as stationary power plants or large boats. The first engines were heavy, weighing as much as 250 pounds per horsepower. They could not compete with the gasoline engine used on land vehicles where weight was a more important factor. Today, diesel engines are much lighter in weight and, of course, are commonly found on all types of trucks, heavy road machinery, and railroad locomotives. Some of today's engines weigh as little as 7 pounds per horsepower.

EXTERNAL COMBUSTION

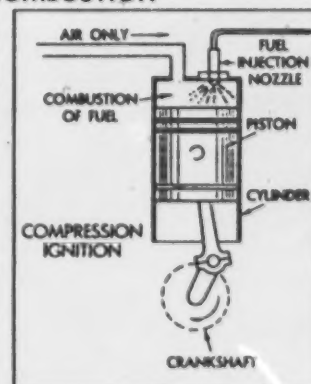


Steam Engine

INTERNAL COMBUSTION



Gasoline Engine



Diesel Engine

Comparison of Combustion Systems.

With a diesel engine, only AIR is forced into the cylinder. Since the compression ratio of a diesel is much higher (16 to 1) than a gasoline engine (8 to 1), the air in the cylinder heats up to 1000 deg. F (538 C) or more when compressed rapidly. Just before the piston reaches top dead center (TDC), the fuel injector sprays a measured amount of fuel into the cylinder. The heated air ignites the fuel and the resulting expanding gases produce the power stroke. For this reason, the engine is sometimes called a COMPRESSION IGNITION engine.

The diesel engine is more efficient than the gasoline engine. It consumes less fuel to produce comparable power — in a truck-size diesel engine, the greatest amount of fuel injected into a cylinder would be a drop about the size of a match head. Increased efficiency is due directly to the high compression ratio. However, the diesel engine is slightly noisier than a gasoline engine and many make a particular "rapping" sound when operating.

Two cycle and four cycle diesel engines are manufactured. Four cycle diesel engines operate on the same principle as four cycle gasoline engines — the cylinder fires once every two revolutions of the crankshaft.

The two cycle diesel engine, Fig. 11-4, has a power stroke every revolution, can produce about twice the power of a four cycle diesel of the same size and about the same weight. However, getting sufficient air into the cylinder in a very short period of time without the help of pumping action of the piston requires the use of a BLOWER. The blower, most commonly of the ROOTS type, forces air into an air chamber that completely surrounds the lower part of the cylinder. When the piston reaches bottom dead center (BDC) the ports are uncovered and air rushes into the cylinder. The exhaust valves open and the blast of incoming air pushes the burned gases out. Ordinarily, more air is forced into the cylinder than

is needed. As the excess air escapes, it pulls any remaining exhaust gases out of the cylinder and, in addition, cools the exhaust valves. See Fig. 11-5 for the operation of a two cycle diesel engine.

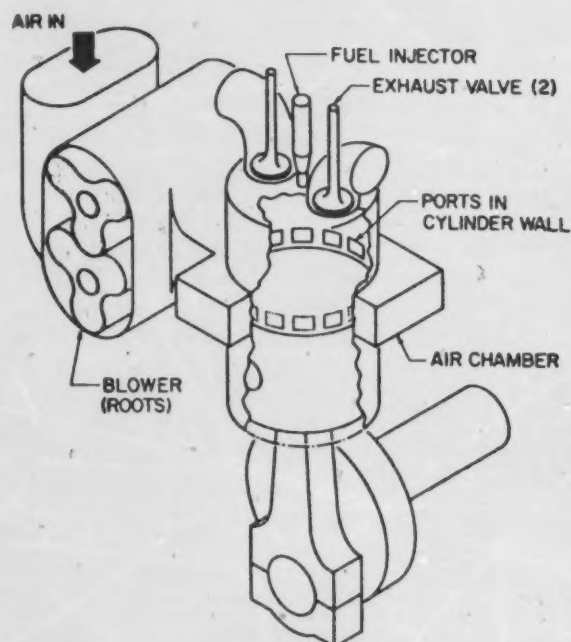


Fig. 11-4. The two cycle diesel engine.

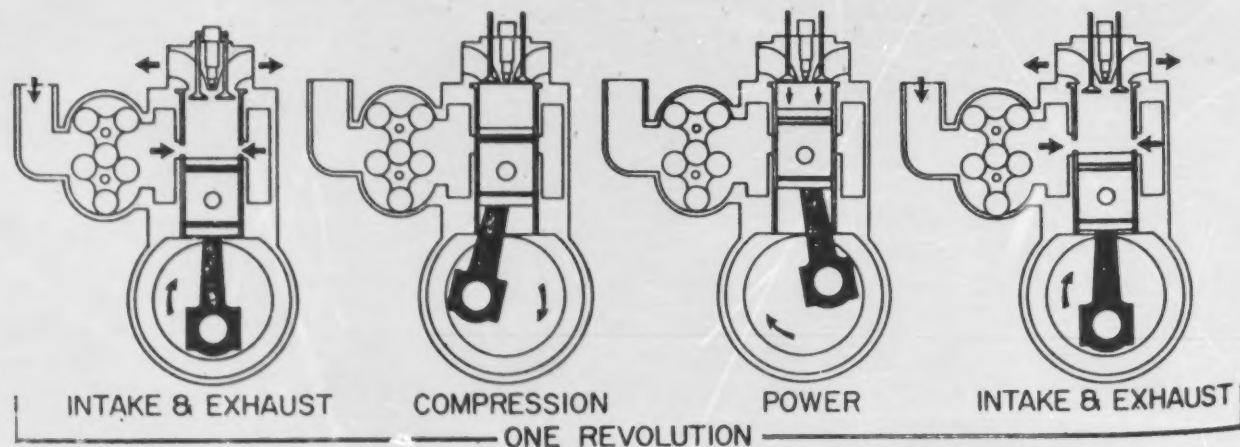
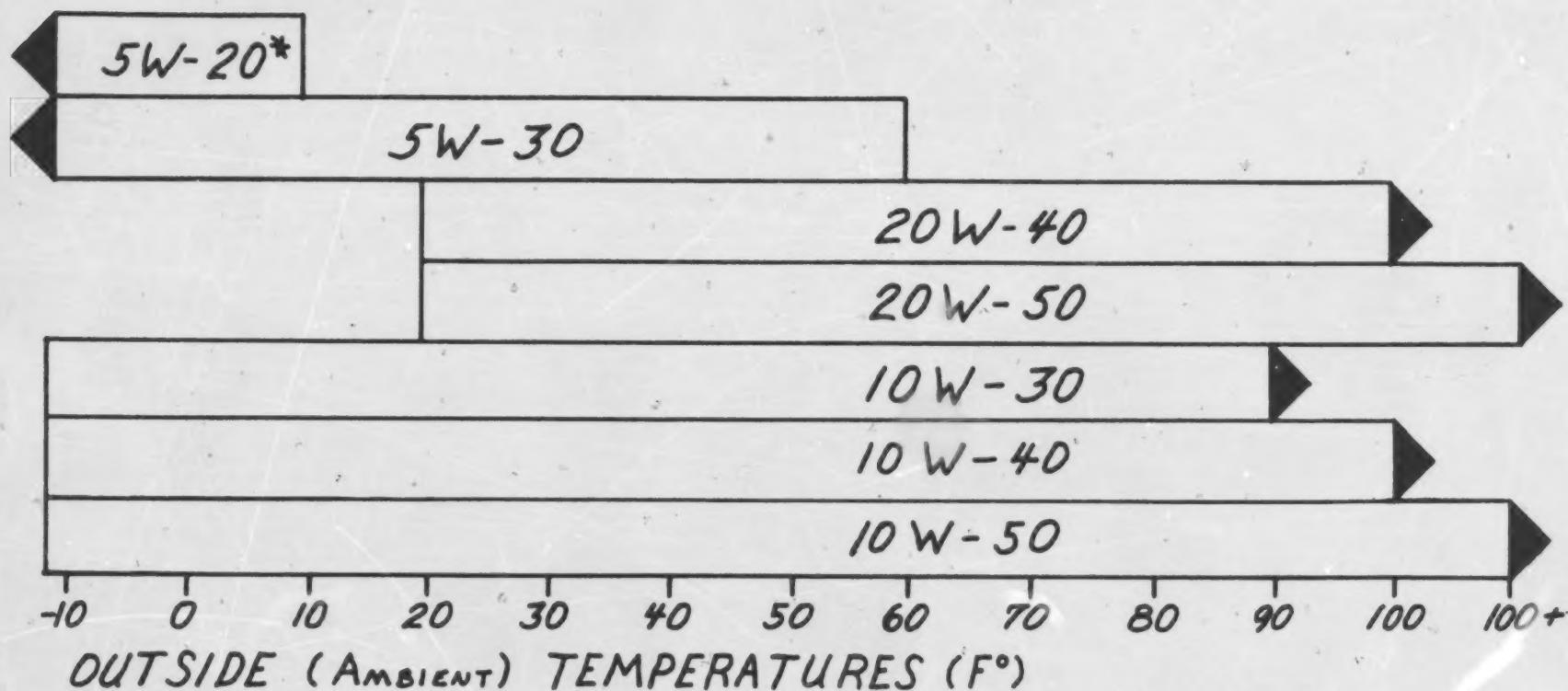


Fig. 11-5. How the two cycle diesel operates.

TEMPERATURE RANGES FOR DIFFERENT VISCOSITY GRADES



* NOT RECOMMENDED FOR SUSTAINED,
HIGH SPEED DRIVING

Study them so that you can save your engine and your money.

Dirt causes one-half the engine failure of all engines. Keep your engine clean. Never allow dirt to get into engines.

Overspeeding an engine causes excessive wear. Do not override the governor, or speed control, on your engine.

Low oil prevents proper lubrication and rapid engine failure.

Engine overload causes overheating and parts failure.

Major repairs should always follow the manufacturer's specifications.

There are four common causes of early engine failure. They are dirt, excessive speed, low oil, and overload. These four things cost you money. They are illustrated in Figure 7-1.

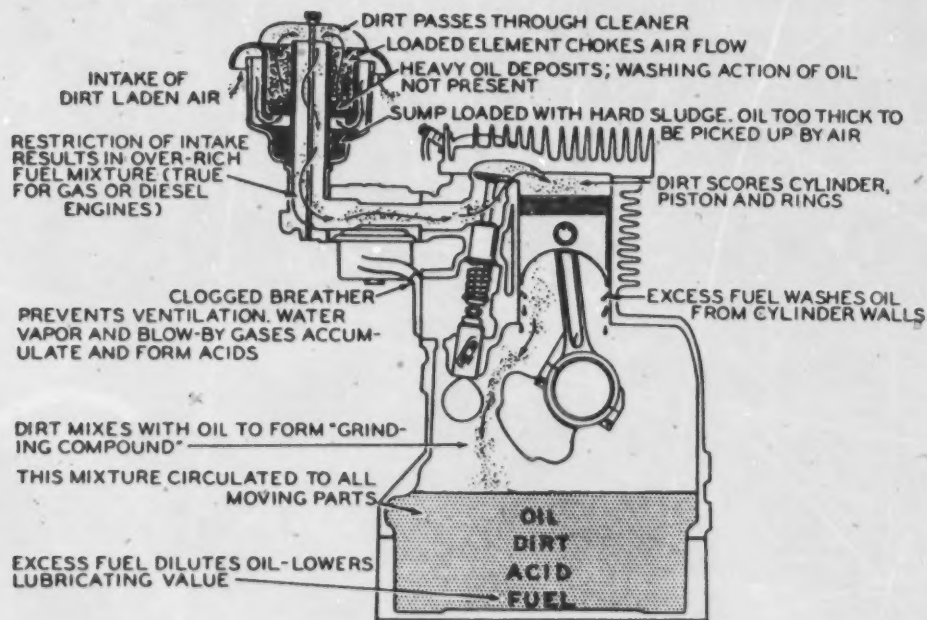


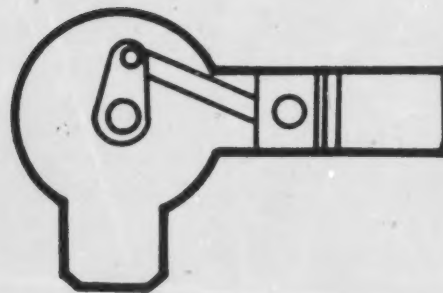
FIGURE 7-1

Dirt, excessive speed, low oil, and overload are the most frequent causes of engine failure. (Courtesy Onan Corporation)

CYLINDER POSITIONS



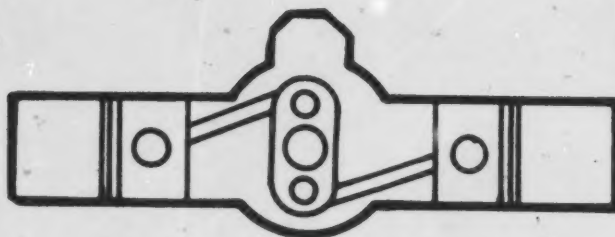
Vertical



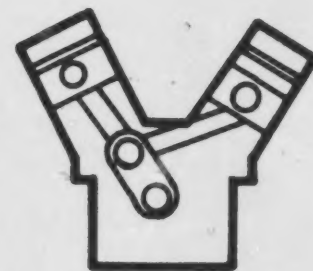
Horizontal



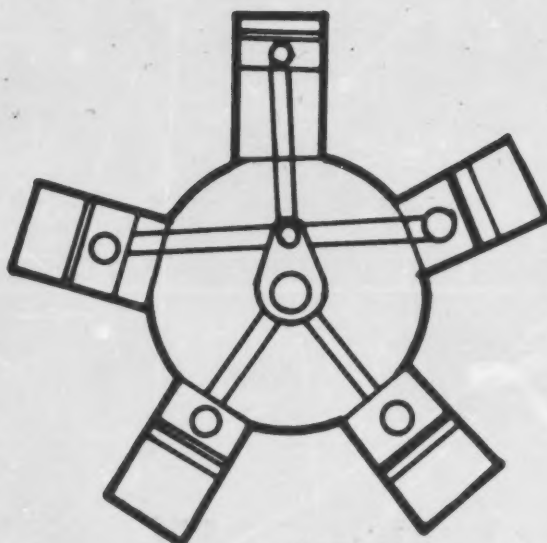
Inverted



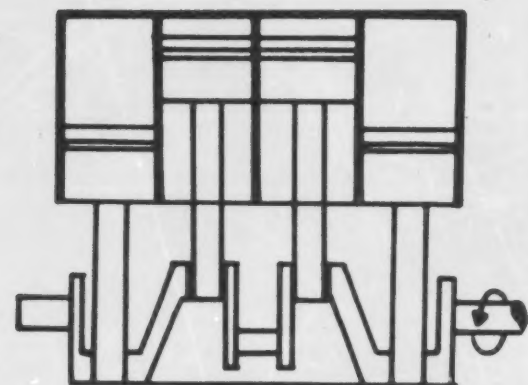
Opposed



V-type



Radial

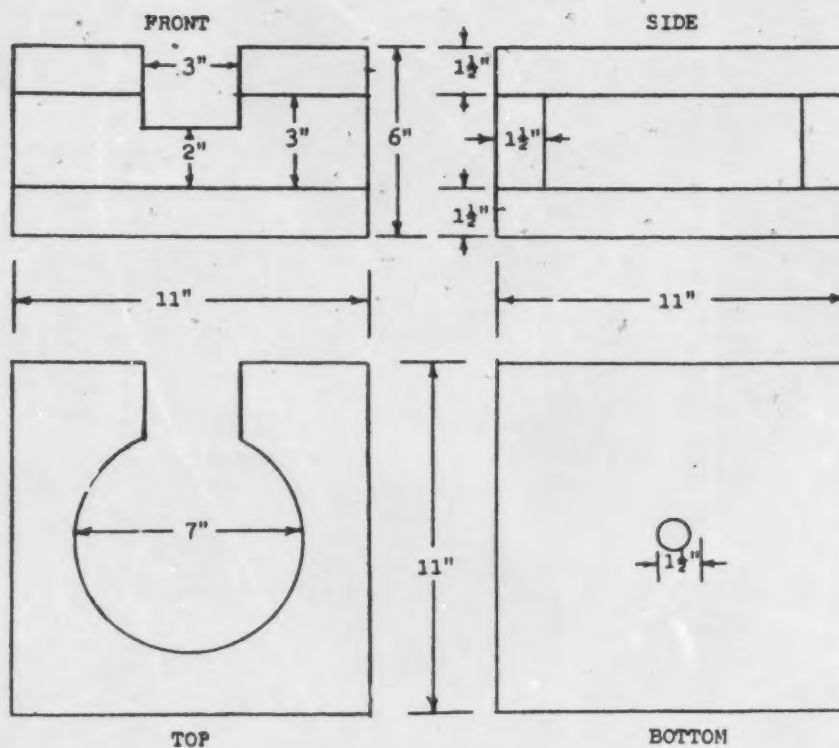
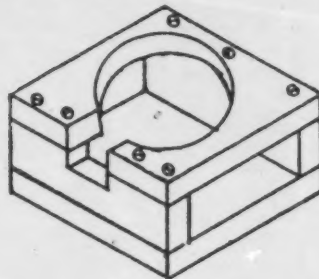


In Line

Student Activity #1

This engine stand should be made of hardwood. It is assembled with wood screws. This stand is Not Available from the factory.

Upon completion of the engine stand, the engine should be carefully positioned on the stand and mounting holes scribed. The engine is then removed and the holes drilled. Should the stands be used for more than one engine type or design, different holes may be required.



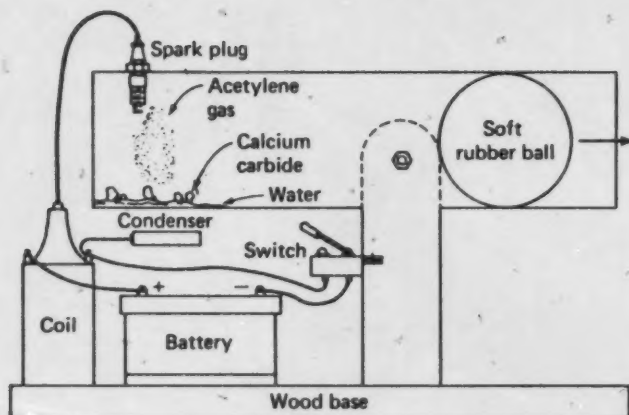


FIGURE 1-12
The carbide cannon
shown is a heat engine.

Make a carbide cannon. You will need to get the following list of materials and supplies.

- 1 large can (1-gallon or 5-quart size)
- 1 large, soft, rubber ball
- 1 spark plug
- 1 high tension coil (A used coil is fine, but check it to make sure it works.)
- 1 battery or transformer for power supply
- 1 switch or breaker-point assembly
- 1 can of calcium carbide for fuel

Construct the cannon as shown in Figure 1-12. *Make sure you use the cannon safely.* The cannon is not dangerous, but it does make a big bang. The ball could break a window. Do not allow anyone to stand in front of the cannon when it is fired.

Student Activity #3

Lab Station _____

Name _____

Name _____

Engine Name and Type _____ Two-Cycle Four-Cycle

Serial Number _____

Engine Model Number _____

Torque Specifications - cylinder head _____

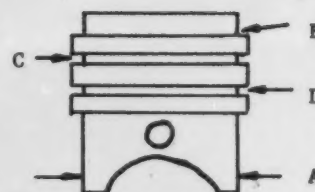
connecting rod _____

Piston Skirt Diameter A _____ Standard _____ Acceptable? Yes No

Ring Groove Clearance B _____ Standard _____ Acceptable? Yes No

Ring Groove Clearance C _____ Standard _____ Acceptable? Yes No

Ring Groove Clearance D _____ Standard _____ Acceptable? Yes No

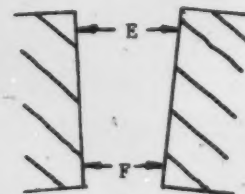


Cylinder Diameter E _____ Standard _____ Acceptable? Yes No

Cylinder Diameter F _____ Standard _____ Acceptable? Yes No

Cylinder Out-of-Round _____ Standard _____ Acceptable? Yes No

Cylinder Taper _____ Standard _____ Acceptable? Yes No



Connecting Rod Side Clearance G. _____ Standard _____ Acceptable? Yes No

Connecting Rod Journal Diameter H _____ Standard _____ Acceptable? Yes No

Connecting Rod Journal Diameter I _____ Standard _____ Acceptable? Yes No

Connecting Rod Journal Taper _____ Standard _____ Acceptable? Yes No

Connecting Rod Out-of-Roundness _____ Standard _____ Acceptable? Yes No

Connecting Rod Journal and Bearing Clearance Standard _____

Flastigage Test Results _____ Acceptable? Yes No



Crankshaft Diameter J _____ Standard _____ Acceptable? Yes No

Crankshaft Diameter K _____ Standard _____ Acceptable? Yes No

Crankshaft Diameter L _____ Standard _____ Acceptable? Yes No

Crankshaft Diameter M _____ Standard _____ Acceptable? Yes No

Crankshaft Out-of-Round JK _____ Standard _____ Acceptable? Yes No

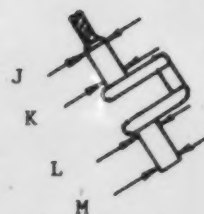
Crankshaft Out-of-Round LM _____ Standard _____ Acceptable? Yes No

Crankshaft Taper JK _____ Standard _____ Acceptable? Yes No

Crankshaft Taper LM _____ Standard _____ Acceptable? Yes No

Crankshaft Bearing Diameter- Internal N _____ Standard _____ Acceptable? Yes No

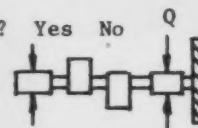
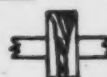
Crankshaft Bearing Diameter- Internal O _____ Standard _____ Acceptable? Yes No



Camshaft Journal Diameter P _____ Standard _____ Acceptable? Yes No

Camshaft Journal Diameter Q _____ Standard _____ Acceptable? Yes No

Camshaft Wear Pattern - Acceptable? Yes No



Valve Stem Diameter R _____ Standard _____ Acceptable? Yes No

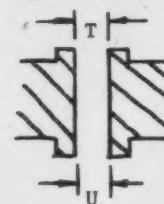
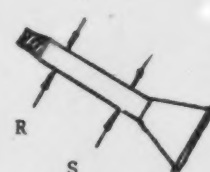
Valve Stem Diameter S _____ Standard _____ Acceptable? Yes No

Valve Stem Taper RS _____ Standard _____ Acceptable? Yes No

Valve Guide Diameter T _____ Standard _____ Acceptable? Yes No

Valve Guide Diameter U _____ Standard _____ Acceptable? Yes No

Valve Guide Taper TU _____ Standard _____ Acceptable? Yes No



BROKEN, DAMAGED, OR INCORRECT PARTS-

Student Activity #4

Build a Go-Kart

Student built go-karts are excellent ways of increasing interest.

A most satisfactory way of including this activity is to have the students divide into teams of 5 or 6 students.

Each team will then purchase an old go-kart and rebuild the engine.

Minor repairs may be needed to put the go-kart into operation. This usually can be done with little effort in a short time.

The students may wish to purchase the go-kart as a team and after the repairs are made, sell the finished go-kart for a profit.

One alternate method is to have the school acquire 5 or 6 go-kart frames and have the teams rebuild old engines to be mounted on them.

Time trials and competition may well help to stimulate the students into extra effort.

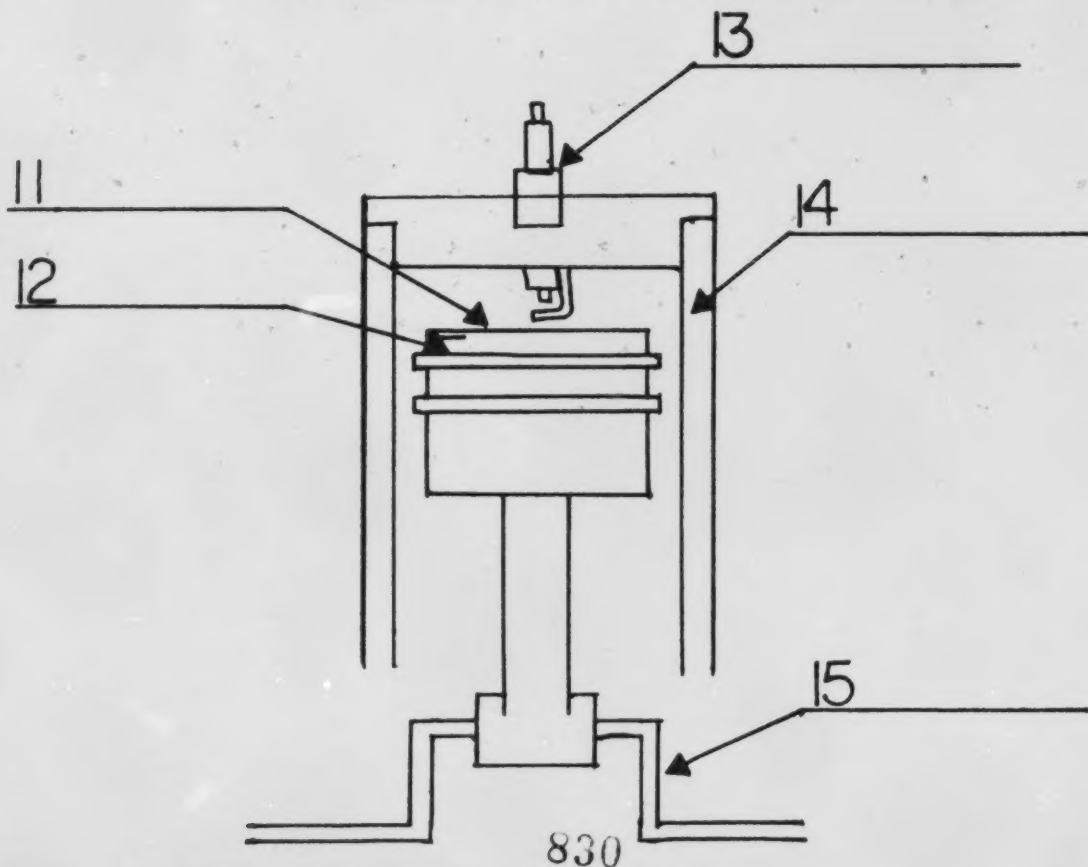
SUGGESTED TEST

I. TRUE/FALSE

1. _____ A gasoline engine is a spark ignition engine.
2. _____ A diesel engine is a compression ignition engine.
3. _____ A water turbine is a heat engine.
4. _____ A steam engine is a heat engine.
5. _____ A diesel engine must have a spark to ignite the fuel mixture.
6. _____ No spark plug is needed in a gasoline engine.
7. _____ A magnet sprays fuel into the cylinder.
8. _____ Timing is the procedure of placing the valves and spark so that they work in the proper sequence.
9. _____ A coil is necessary in a diesel engine.
10. _____ The spark plug gets its current from the battery.

II. IDENTIFY

11 - 15. Identify the parts in the drawing below by writing in the correct name for the part on the line beside each number.



EQUIPMENT/SUPPLIES

1. One small 2-cycle internal combustion engine
2. One small 4-cycle internal combustion engine
3. One 3/8" drive socket set 3/8" to 3/4"
4. One set of open end wrenches
5. One common screw driver
6. One Phillips screw driver
7. One spark plug socket
8. One pair of slip-joint pliers
9. One needle nose pliers
10. One spark tester (Briggs & Stratton #19051)
- *11. One tool kit (Briggs & Stratton #291661)
12. One flywheel puller (Briggs & Stratton #19068)
13. One flywheel puller (Briggs & Stratton #19069)
14. One ring compressor (Briggs & Stratton #19070)
15. One starter wrench (Briggs & Stratton #19114)
16. One flywheel puller (Briggs & Stratton #19165)
17. One flywheel holder (Briggs & Stratton #19167)

*Optional--includes tools #19051, 19068, 19069, 19070, 19114, 19122, 19165, 19167.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

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Instructional Section:

PRIME MOVERS

Title of Unit:

BRAYTON CYCLE INTERNAL COMBUSTION ENGINES

DESCRIPTION OF UNIT

This unit will cover internal combustion engines which belong to the Brayton Cycle class. It will provide an overview of jet and turbine engines. The basic parts of jets and turbines will be explained. The use of Brayton Cycle engines in the transportation field will be discussed. The Brayton Cycle engines as important prime movers in the field of transportation as well as their future are covered. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVE

After completion of this unit the student will be able to describe the Brayton Cycle engines as prime movers. The student will be able to give several applications of Brayton Cycle engines in the field of transportation. The student will be able to demonstrate an understanding of the Brayton Cycle engine by sketching a typical engine and labeling the parts and processes.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Match selected terms and definitions.
2. Describe orally or in writing the Brayton Cycle.
3. List and describe four uses of Brayton Cycle engines.
4. Make a sketch of a typical Brayton Cycle engine and label the basic parts and sections.

OUTLINE OF CONTENT

The Outline of Content is brief. Several of the references at the end of this unit cover Brayton Cycle engines. Walker's text Exploring Power Technology is especially good and is recommended as a prime source.

I. The Brayton Cycle Engine

The Brayton Cycle engine is an engine which has four separate areas in which the four functions—intake, compression, power and exhaust occur continually.

- A. Ramjet
- B. Pulsejet
- C. Turbojet
- D. Turbine Engine
- E. Rocket

TEACHER ACTIVITIES

1. Prepare terminology sheet for students.
2. Prepare transparencies illustrating operating principles of the turbojet (use diagram on p. 140 in Walker, Exploring Power Technology).

STUDENT ACTIVITIES

1. Study terminology sheet and transparency material.
2. Draw and label a typical Brayton Cycle engine.

REFERENCES/RESOURCES

References:

1. Bohn, Ralph C. and MacDonald, Angus J., Power: Mechanics of Energy Control, Bloomington, Ill.: McKnight & McKnight, 1970.
2. Geil, John J. and Johnson, Stephen, Energy and Transportation: Industry and Careers, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.
3. Stephenson, George E., Power Technology, Albany, New York: Delmar Publishers, 1973.
4. Walker, John R., Exploring Power Technology, South Holland, Ill.: Goodheart-Willcox Co., 1976.
5. Worthington, Robert M., Margules, Morton and Crouse, William, General Power Mechanics, New York: McGraw-Hill Co., 1968.
6. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

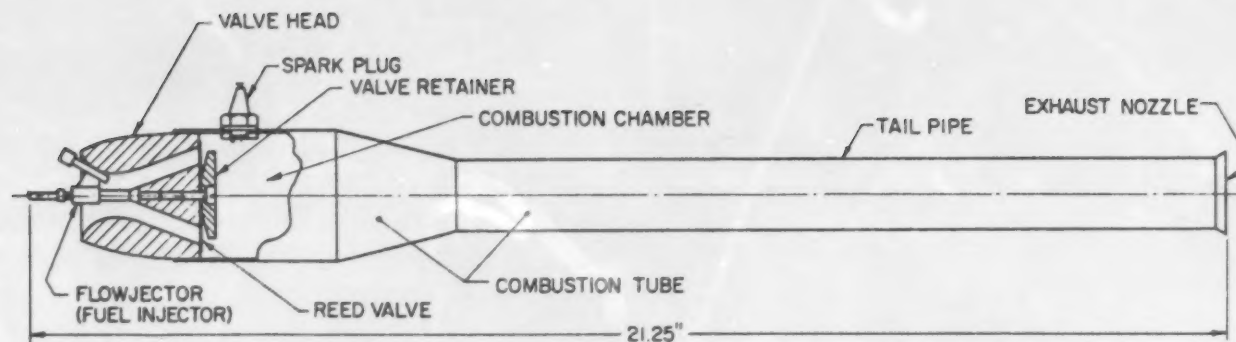
Resources:

1. Terminology Sheet
2. Transparencies

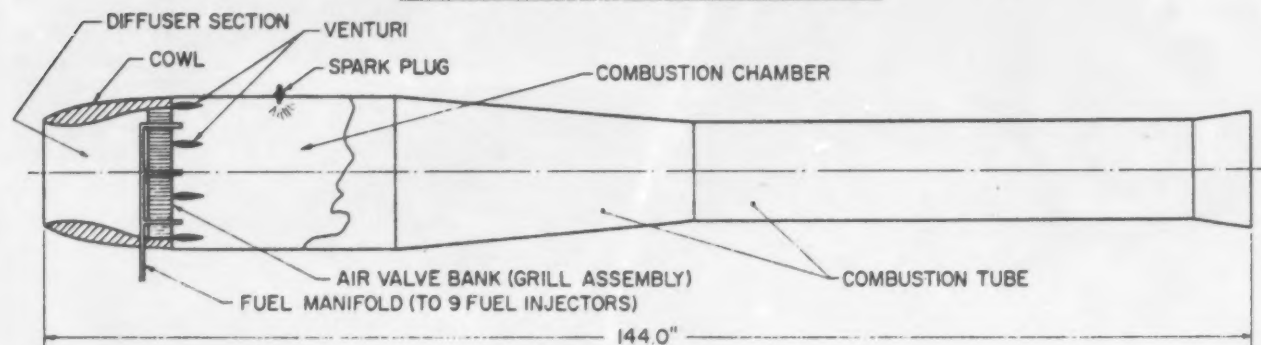
Terms and Definitions

1. ATHODYD--Ramjet short for "Aerothermodynamic Duct".
2. Axial flow--Jet engine which uses many rows of rotating (rotors) and stationary blades (stators) to move air through engine and increase pressure.
3. Bipropellant system--Fuel and oxidizer in two separate materials.
4. Centrifugal flow--Turbojet design which forces air outward and into combustion chamber.
5. Combustion chamber--Chamber in which fuel is burned to produce heat and pressure.
6. Flying stove pipe--Slang term for ramjet engine.
7. Grain--Solid fuel component.
8. Heat exchanger--Device which transfers heat energy from one gas or liquid to another gas or liquid without mixing--as a radiator.
9. Hypergolic--Fuels which ignite when mixed.
10. Hypersonic--Above twice the speed of sound Mach two.
11. Liquid fuel rocket--Rocket which uses one or more liquid fuel materials.
12. Mach--Speed of sound at sea level, about 760 mph.
13. Monopropellant--Fuel and oxidizer combined in one substance--such as powder.
14. Oxidizer--Oxygen or material with high oxygen content which oxidizes or combines with fuel for rapid burning.
15. Ramjet--Jet engine with no moving parts.
16. Rocket--A device or reaction engine which is propelled by the ejection of fast moving material, usually gases.

17. Scramjets--Hypersonic jets up to Mach six.
18. Solid fuel rocket--Rocket which uses fuel in solid or powder state.
19. Sonic--Speed of sound about 760 mph at sea level or Mach one.
20. Subsonic--Below the speed of sound or Mach one.
21. Supersonic--Above speed of sound or Mach one.
22. Tail pipe--Tube through which the exhaust gases escape.
23. Thrust--Term given to rate power output like horsepower.
24. Turbojet--Jet engine which uses exhaust gases to drive turbine for power to compress intake air.



DYNA-JET MODEL PULSEJET ENGINE

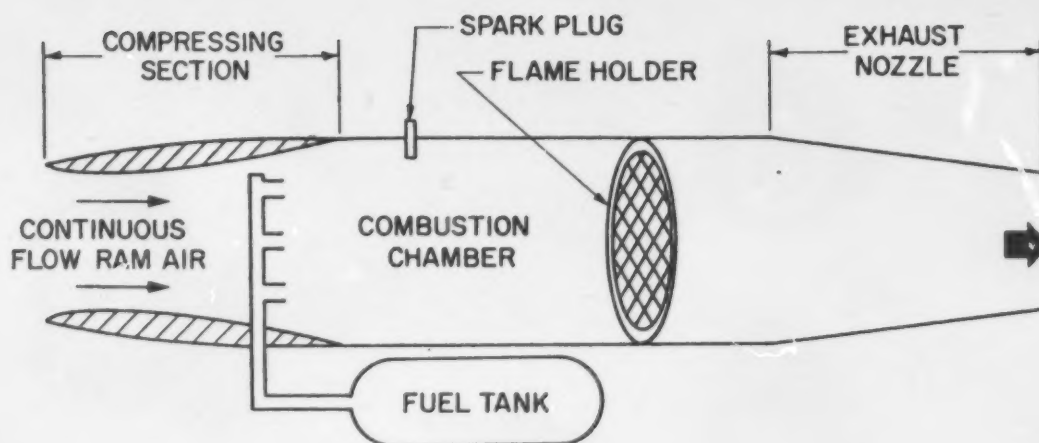


TYPICAL PULSEJET OF THE SCHMIDT TYPE

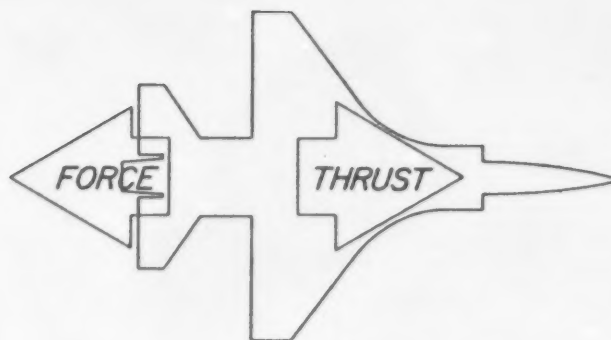
Typical pulsejet engines that have been used commercially.

PROPULSION METHOD	DIAGRAM OF UNIT	OVERALL EFFICIENCY(%)	RELATIVE FRONTAL AREA (DRAG)	RELATIVE WEIGHT OF FUEL FOR GIVEN DURATION	FLIGHT SPEED
ROCKET					SUPERSONIC
RAMJET					SUPERSONIC
PULSEJET					SUBSONIC AND SUPERSONIC
TURBOJET					SUBSONIC AND SUPERSONIC
TURBOPROP					SUBSONIC
SUPERCHARGED RECIPROCATING ENGINE					SUBSONIC

RAMJET ENGINES

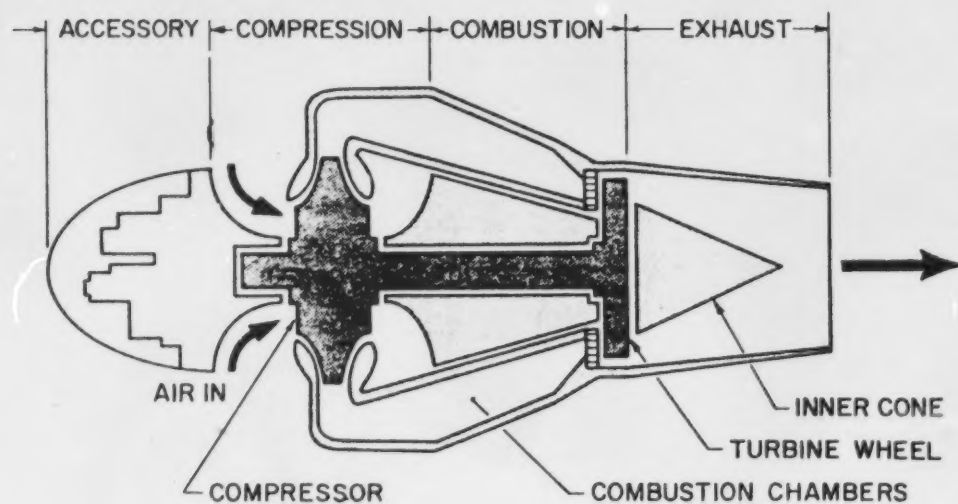


Typical ramjet engine.



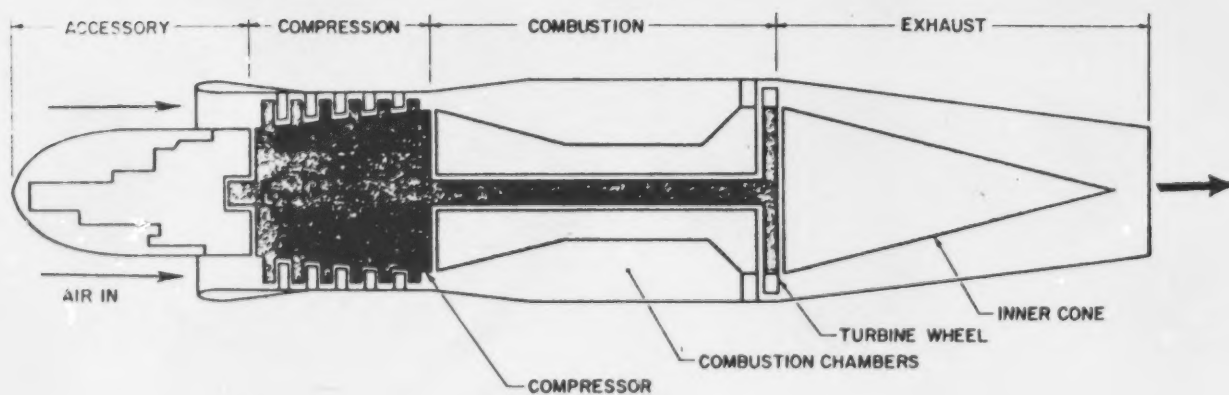
The rearward expulsion of hot gases (FORCE) creates an opposite reaction that propels the craft forward (THRUST).

CENTRIFUGAL FLOW TURBOJET ENGINE



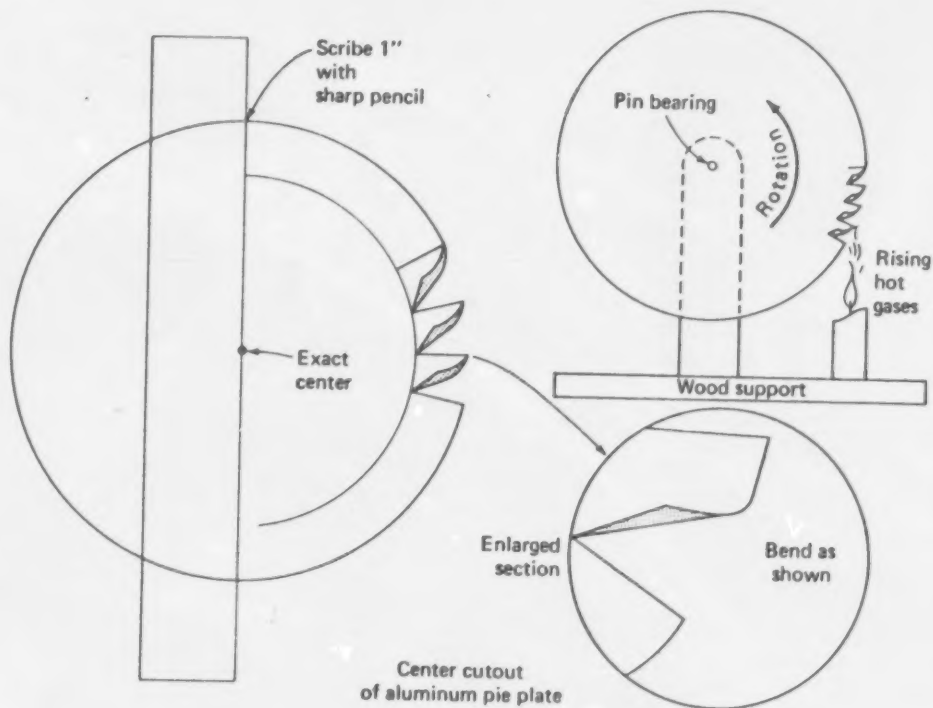
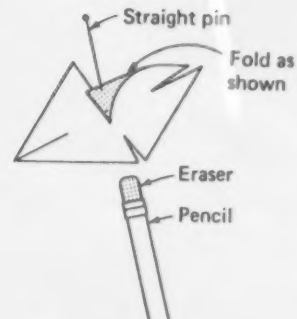
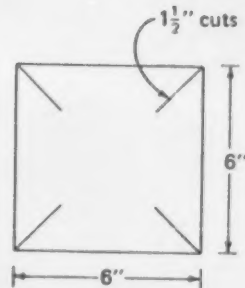
Centrifugal flow turbojet engine.

AXIAL FLOW TURBOJET ENGINE



Axial flow turbojet engine.

The common pinwheel shown here is an easy turbine to build.



The metal-wheel turbine is very much like the turbine used in airplane engines.

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

PRIME MOVERS

Title of Unit:

STIRLING CYCLE EXTERNAL COMBUSTION ENGINES

DESCRIPTION OF UNIT

This unit will describe the Stirling Cycle external combustion engine. The operation of a typical Stirling Cycle engine will be covered. The possible future uses of Stirling Cycle engines will be described. The principle of the Stirling Cycle will be covered. The advantages and disadvantages will be covered. Names used to designate Stirling Cycle engines will be included. The materials in this unit are designed for 2 hours of instruction.

UNIT OBJECTIVES

After completion of this unit the student will be able to describe the Stirling Cycle engine and explain the principle of operation. The student will be able to list some of the advantages and disadvantages of the Stirling Cycle engines. The student will be able to describe several names applied to Stirling engines.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Describe orally or in writing the Stirling Cycle.
2. Explain orally or in writing the principle of the Stirling Cycle engine.
3. List three advantages of the Stirling Cycle engine.
4. List three disadvantages of the Stirling Cycle engine.
5. List two other names given to the Stirling Cycle engine.

OUTLINE OF CONTENT

Note: Walker, John R., Exploring Power Technology; Goodheart-Wilcox Co., Inc., South Holland, Ill., 1976, p. 198.

The Stirling Cycle--External combustion or external heat source engine which uses a heat exchanger system to transfer heat energy to the working fluid inside the engine.

- A. Gas Cycle--Same as Stirling--Sometimes used to designate Stirling Cycle.
- B. Principle of Operation
- C. Parts and Drive Systems
- D. Applications--Ford Motor Co.
- E. Problems and Economy

TEACHER ACTIVITIES

1. Prepare a definition sheet of appropriate terms.
2. Prepare a transparency of the Stirling Cycle. (Use diagram on p. 200 of Walker, Exploring Power Technology.)

STUDENT ACTIVITIES

1. Study terminology sheet and transparencies.
2. Sketch a Stirling Cycle.
3. List advantages and disadvantages of the Stirling Cycle engine.

REFERENCES/RESOURCES

References:

1. Walker, John R., Exploring Power Technology, South Holland, Ill.: Goodheart-Willcox Co., 1976.
2. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, N.J.: Prentice-Hall, 1976.

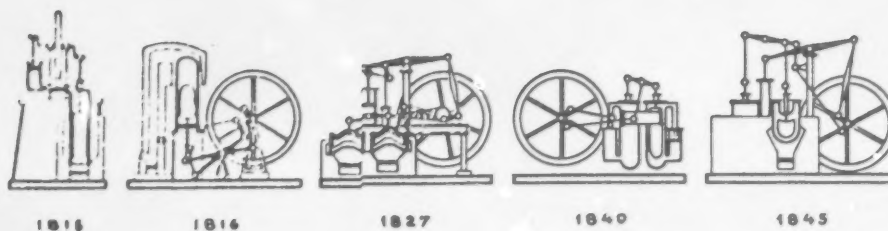
Resources:

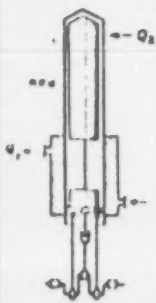
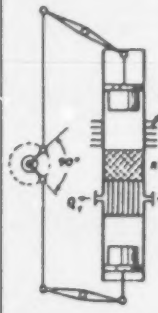
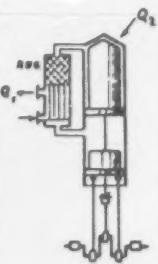
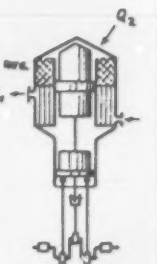
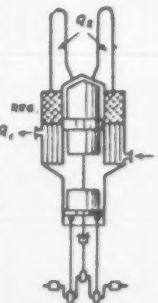
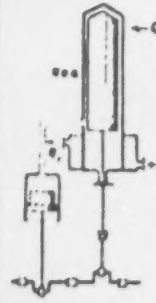
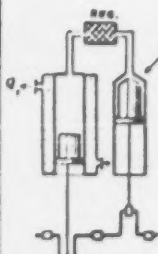
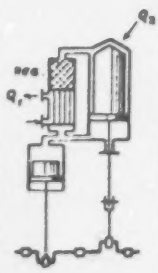
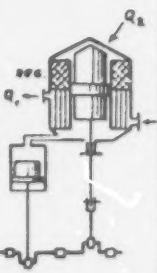
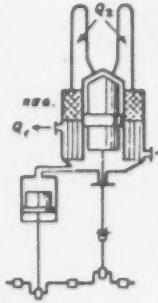
1. Information Sheet
2. Transparency Master (Use diagram on p. 200 of Walker, Exploring Power Technology).

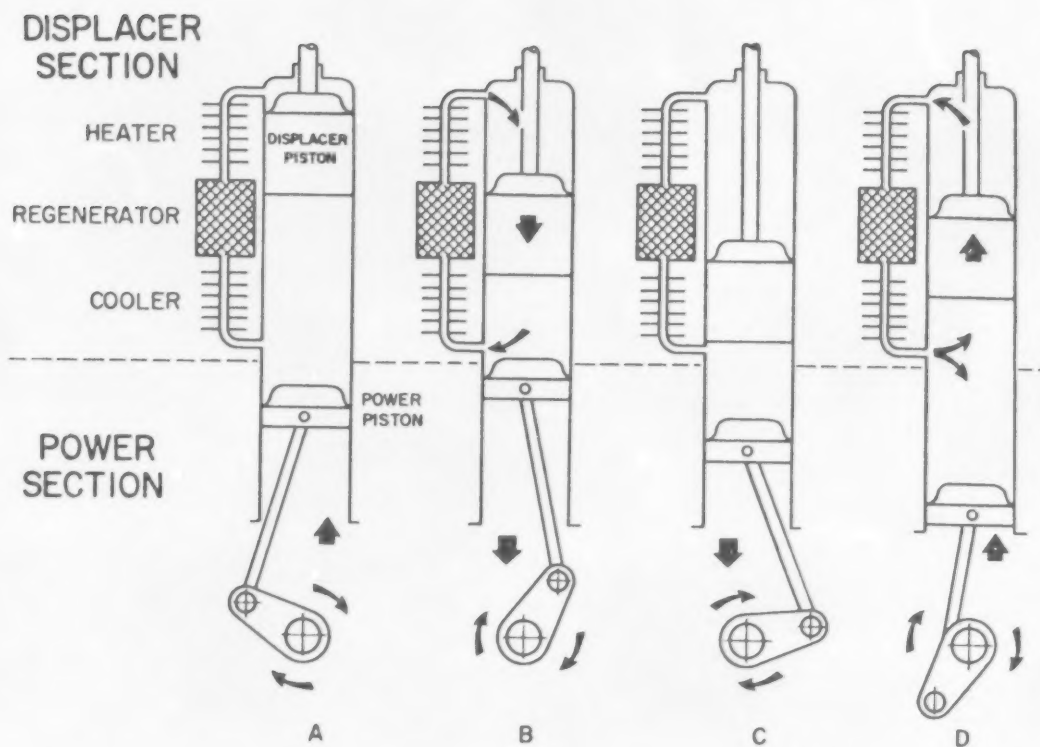
TERMS AND DEFINITIONS

1. Stirling Engine--External combustion engine which uses a heat exchanger to transfer combustion heat energy to the working fluid inside the engine.
2. Displacer piston--Piston which moves gas from hot chamber to cold chamber.
3. Regenerator--A device for absorbing exhaust gases heat and transferring it to the working fluid.
4. Hydrogen--Best working fluid (gas) for Stirling engine but has several problems.
5. Helium--Very good working fluid (gas) for Stirling cycle engines.
6. Freon--Commonly used working fluid (gas) for Stirling cycle engines. Engines are sometimes referred to as "Freon Engines".
7. Heater--Burner or other device for heat energy input to Stirling cycle engine. May use fuel such as oil, gasoline, kerosene, wood or coal or some other source such as sunlight.

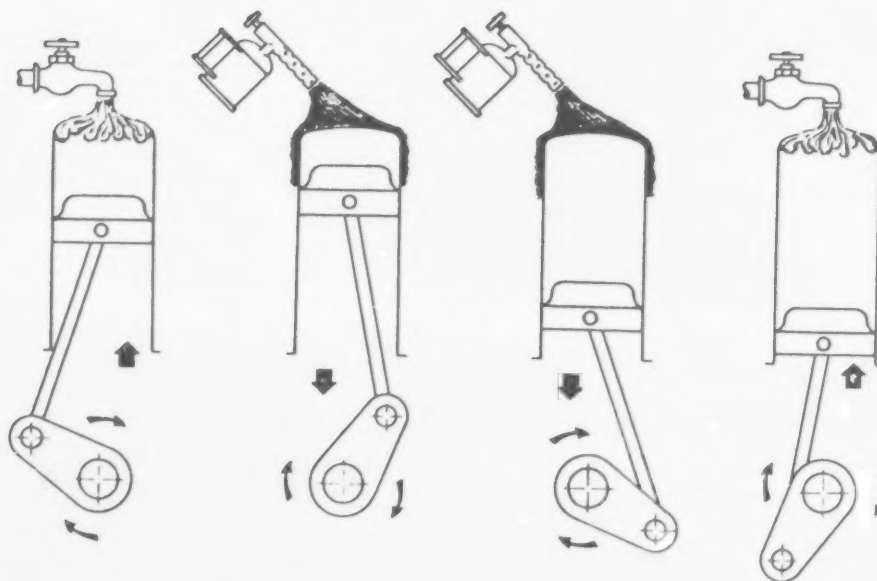
1815

STIRLING

	PISTON-DISPLACER SUBSTITUTES REGENERATOR	CIRCULATION OF THE WORKING MEDIUM			HEAT SUPPLIED OUTSIDE CYLINDER
		INSIDE	OUTSIDE	AROUND	
STIRLING 1815 LEHMANN 1866 BRIDGEMAN 1880					
	STIRLING 1815 LEHMANN 1866 BRIDGEMAN 1880	DE BRAY 1847 (PHILIPS)	RINIA 1846 (PHILIPS)	MEIJER 1858 (PHILIPS)	
STIRLING 1815 LEHMANN 1866 BRIDGEMAN 1880					
	STIRLING 1815 LEHMANN 1866 BRIDGEMAN 1880	DE BRAY 1847 (PHILIPS)	RINIA 1846 (PHILIPS)	MEIJER 1858 (PHILIPS)	

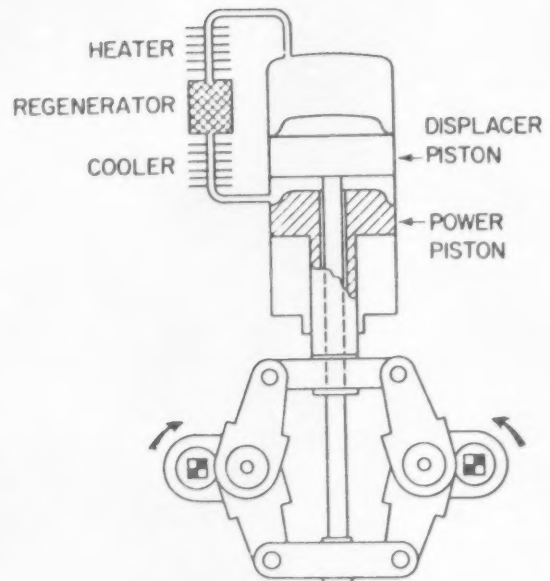
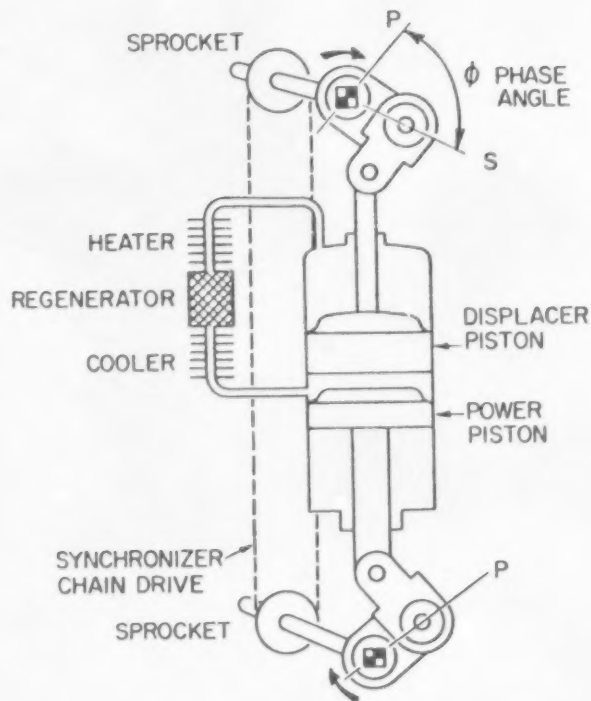


The ideal Stirling cycle. (Ford Motor Co.)



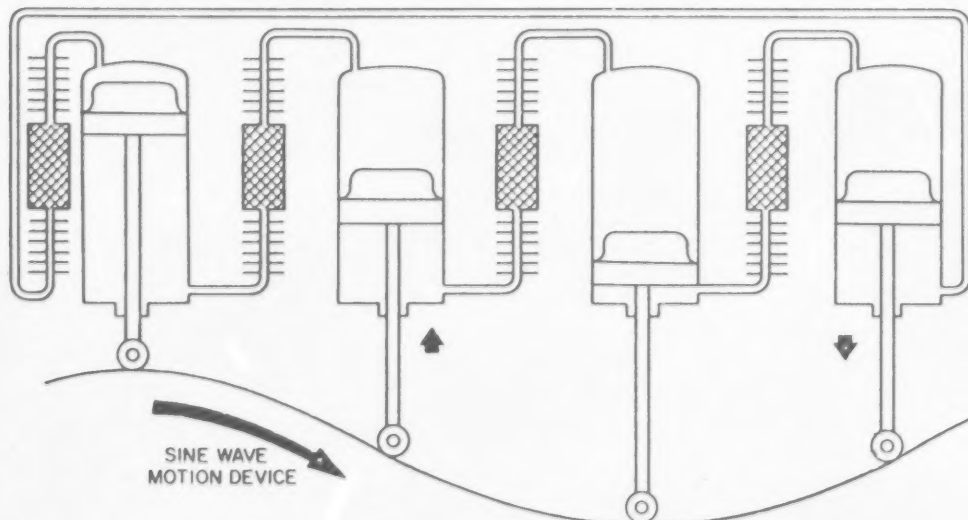
A simple Stirling cycle. (Ford Motor Co.)

The Stirling Engine

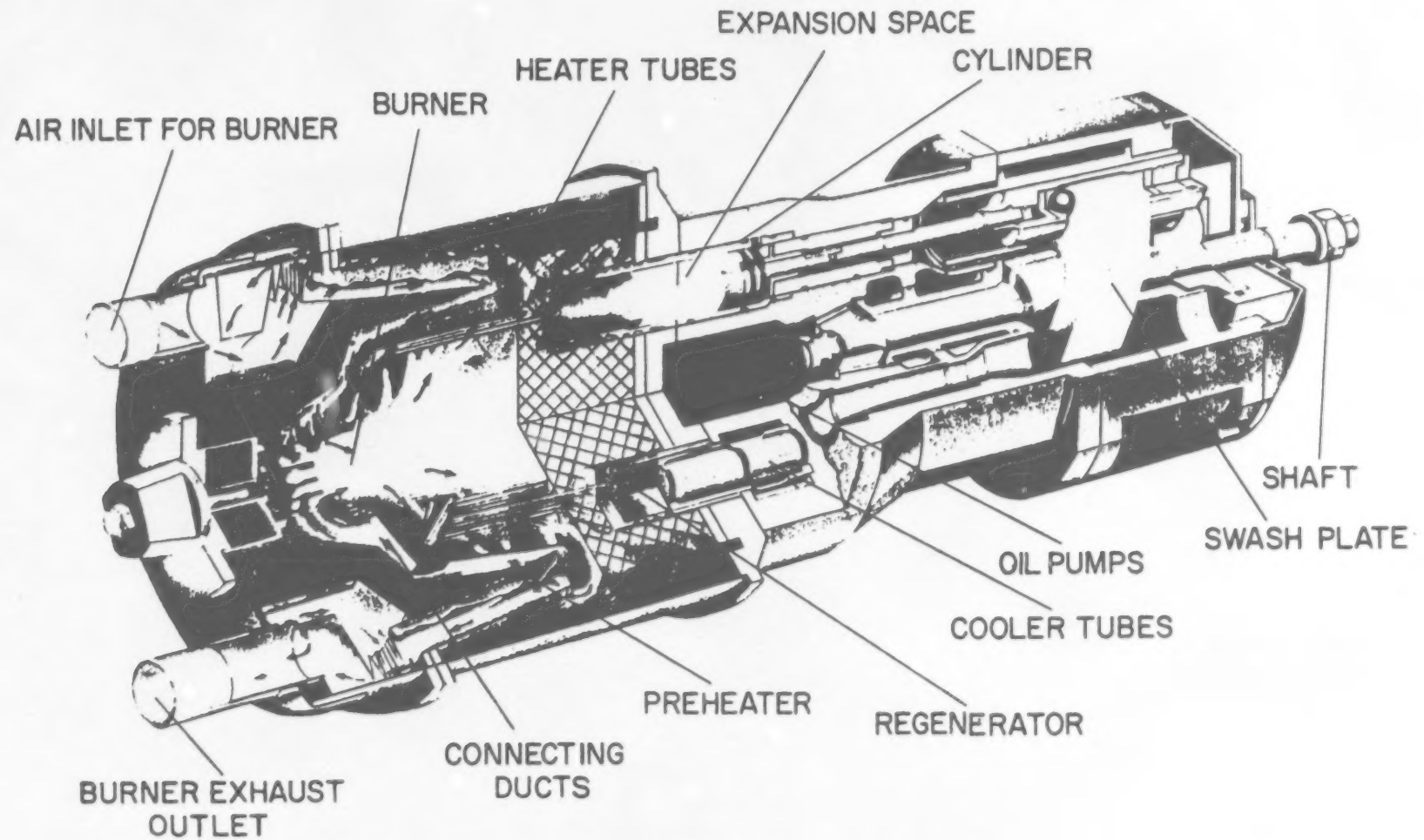


The Rhombic Drive Stirling engine developed by the N.V. Phillips Laboratories of the Netherlands. (Ford Motor Co.)

The power piston and displacer piston are operated in a fixed relationship by sprockets and a chain in this Stirling engine. (Ford Motor Co.)



The RINIA arrangement is often employed for Stirling engines with more than one cylinder. With this type of construction each piston serves as both a power piston and as a displacer piston for the adjacent cylinder. (Ford Motor Co.)



Stirling engine developed to replace 351 CID engine for use in automobiles. It produces about 170 hp.
(Ford Motor Co.)

TENNESSEE INDUSTRIAL ARTS CURRICULUM

TRANSPORTATION

Instructional Section:

PRIME MOVERS

Title of Unit:

RANKINE CYCLE EXTERNAL COMBUSTION ENGINES

DESCRIPTION OF UNIT

This unit will cover the basic concepts as applied to Rankine or steam engines. The description of the Rankine Cycle will be covered. The use of steam engines both piston and turbine as prime movers will be covered. The materials in this unit are designed for 3 hours of instruction.

UNIT OBJECTIVES

After completion of this unit the student will be able to describe the Rankine Cycle. The student will be able to list several types of Rankine Cycle steam engines and tell where they are used. The student will be able to list some advantages and disadvantages of steam engines. The student will be able to demonstrate the Rankine Cycle by the construction of a simple reaction or impulse turbine.

PERFORMANCE OBJECTIVES

After completion of this unit the student will be able to:

1. Describe the Rankine Cycle.
2. Match given terms and definitions.
3. Describe orally or in writing a reaction turbine.
4. Describe orally or in writing an impulse turbine.
5. List 3 transportation devices which use a Rankine Cycle engine.
6. Construct impulse or reaction turbine as instructed.
7. List two advantages and two disadvantages of steam turbine engines.

OUTLINE OF CONTENT

The abbreviated Outline of Content below may be supplemented by several of the references listed at the end of the unit. The text by Walker is good and the publication by Tucker is especially good on current uses and developments of the Rankine cycle engine.

- I. The Rankine Cycle--Steam powered engines--both piston type and turbine.
 - A. Components of Rankine cycle engines--The basic parts of Rankine cycle engines.
 1. Combustion--(external type burners) The firebox or combustion chamber where chemical fuel is burned. It is located outside of the engine proper.
 2. Condensers--Radiator type device where steam is cooled into liquid.
 3. Materials--Steam engines employ many materials of construction. Newer engines employ composite materials such as ceramics and metal or ceramets.
 4. Lubricants--The moving parts of steam engines must be lubricated with oil or synthetic lubricants.
 5. Working fluid--Usually water, but may be a variety of liquid substances which is converted into high pressure steam.
 6. Controls--Throttle value or combustion rate value (fuel valve) and pressure regulators. Also includes reversing control or piston engines.
 - B. Piston type engine--Reciprocating piston engines.
 1. Background--Earliest usable steam engines.
 2. Recent Development
 3. Advantages and Disadvantages
 - C. Turbine engines
 1. Background--Hero's Aelopile
 2. Recent Development
 3. Advantages and Disadvantages

D. Student Research and Development

1. Turbine Construction
2. Future of Rankine Cycle Engine in the Area of Transportation

TEACHER ACTIVITIES

1. Prepare terminology sheet.
2. Prepare transparencies of:
 - A. Schematic of steam engine (Use p. 171 of Bohn, Power: Mech. of Energy Control).
 - B. Schematic of impulse and reaction turbines (Use p. 187 of Stephenson, Power Technology.)
3. Gather materials and instructions for constructing impulse and reaction turbines.

STUDENT ACTIVITIES

1. Study terminology sheet and transparency material.
2. Construct an impulse turbine.
3. Construct a reaction turbine.

REFERENCES/RESOURCES

References:

1. Bohn, Ralph C. and MacDonald, Angus, Power: Mechanics of Energy Control, Bloomington, Ill.: McKnight & McKnight, 1970.
2. Drake, George R., The Repair and Maintenance of Small Gasoline Engines, Reston, Va.: Reston Pub. Co., 1976.
- *3. Lucker, Stephen and Renner, Roy A., An Assessment of the Technology of Rankine Engines for Automobiles, Division of Transportation Energy Conservation, U.S. Energy Research and Development Administration, 1977 (ERDA-77-54)
4. Stephenson, George E., Power Technology, Albany, New York: Delmar Publishers, 1973.
5. Walker, John, Exploring Power Technology, South Holland, Ill.: Goodheart-Willcox Co., 1976.
6. Worthington, Robert M., Margules, Morton and Crouse, William, General Power Mechanics, New York: McGraw-Hill Book Co., 1968.
7. Yadon, James N., Energy and Transportation: Small Engines, Englewood Cliffs, N.J.: Prentice-hall, 1976.

*Free materials--or inexpensive U.S. printing office booklet.

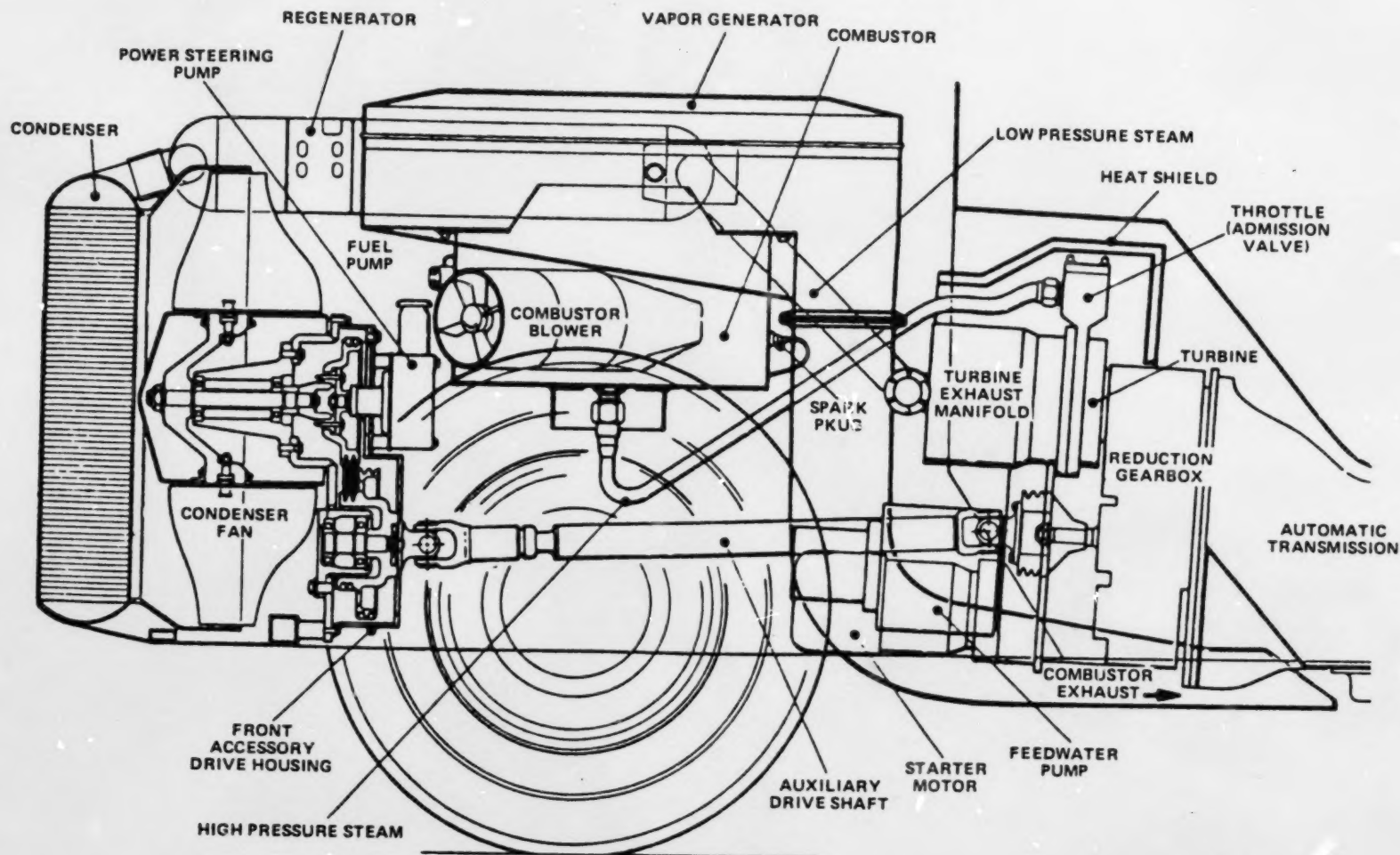
Resources:

1. Terminology Sheet
2. Transparencies

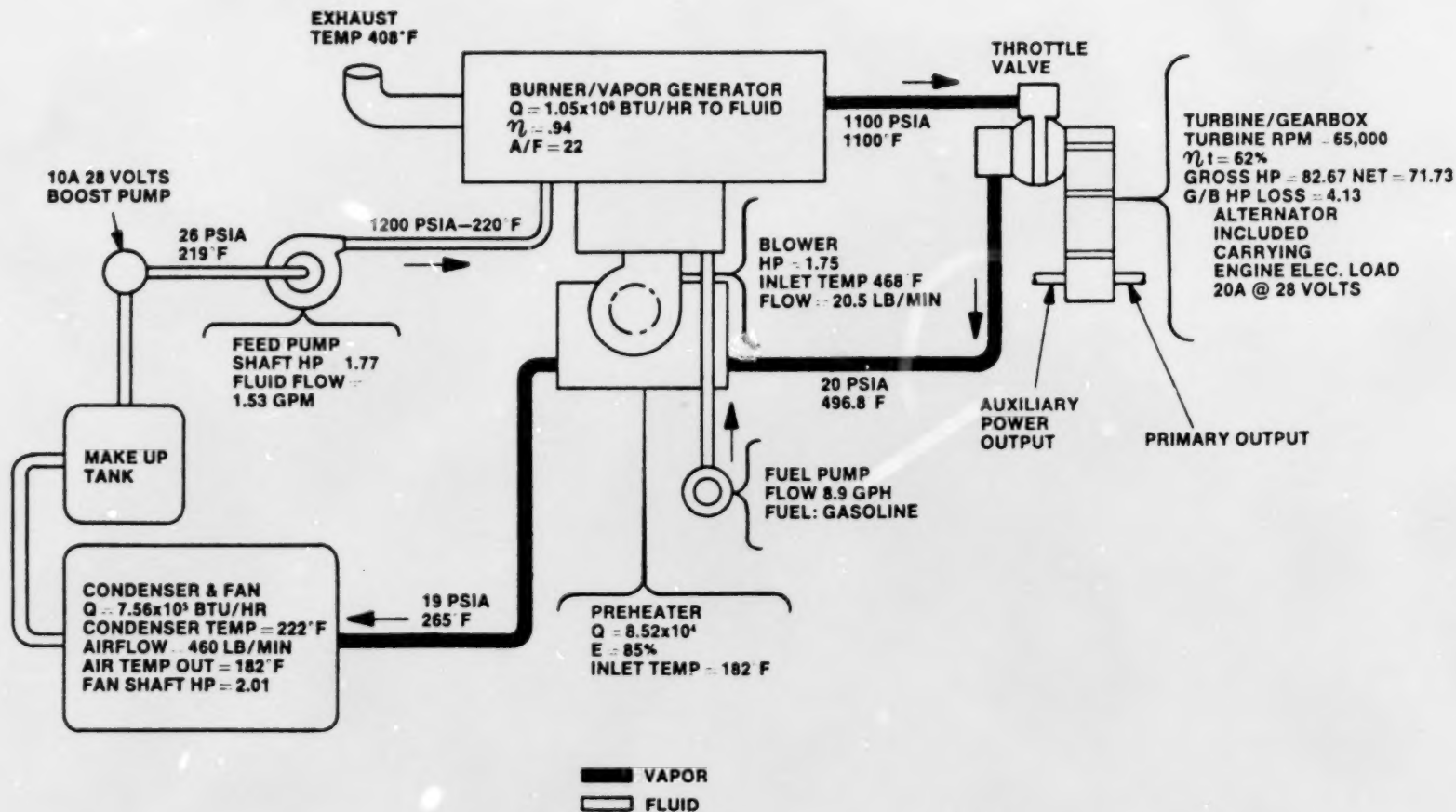
TERMS AND DEFINITIONS

1. Rankine cycle--Steam engine--either piston or turbine.
2. External combustion--Fuel is burned outside of the engine proper and converts liquid into steam or vapor which is used by the engine to develop mechanical power.
3. Reciprocating engine--Piston moves back and forth in cylinder.
4. Turbine--Wheel with a series of blades or "buckets" which are made to spin by steam or vapor.
5. Firebox--External combustion chamber where fuel is burned.
6. Condenser--Radiator like device which is used to cool steam or vapor to fluid state.
7. Expander--Engine--Device which is driven by steam or vapor to produce mechanical power.
8. Impulse engine--Engine driven by jet of high pressure steam or vapor against blades or "buckets."
9. Reaction engine--Engine driven by jets or nozzles located on turbine wheel itself.

VAPOR TURBINE SYSTEM INSTALLATION (AUTOMOBILE)



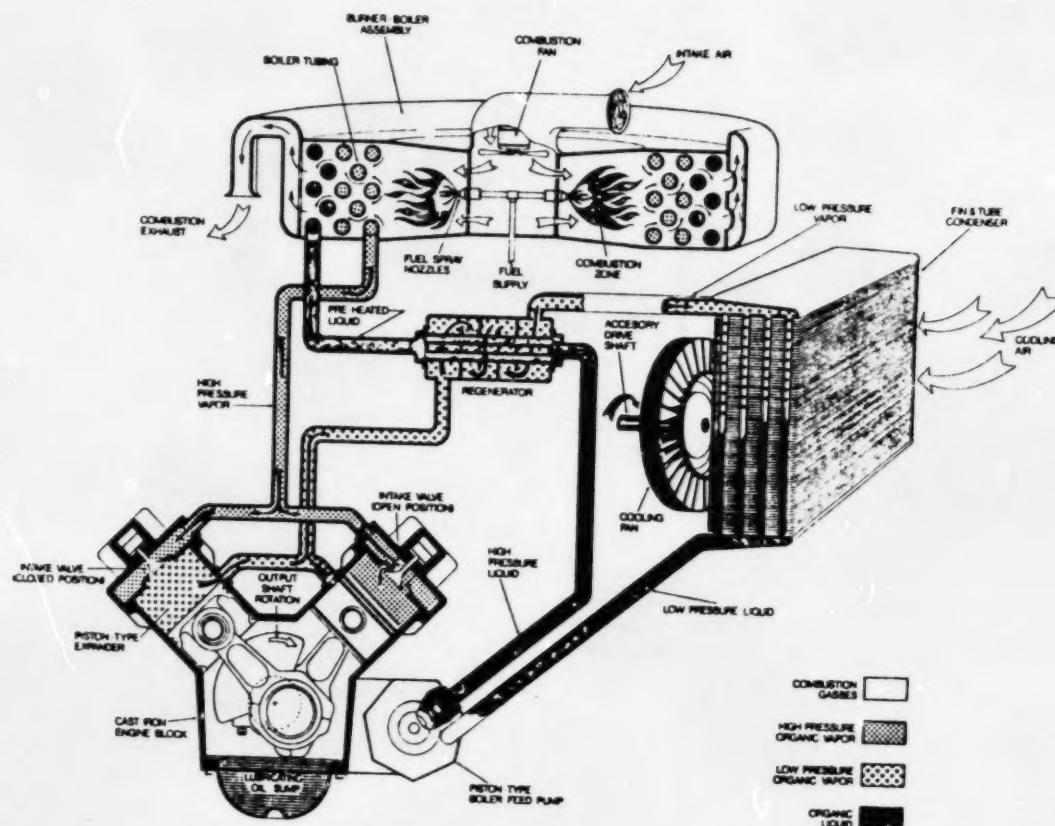
Layout of LMC System in Chevrolet Monte Carlo Automobile



Flow Diagram of LMC Turbine System at Part Load

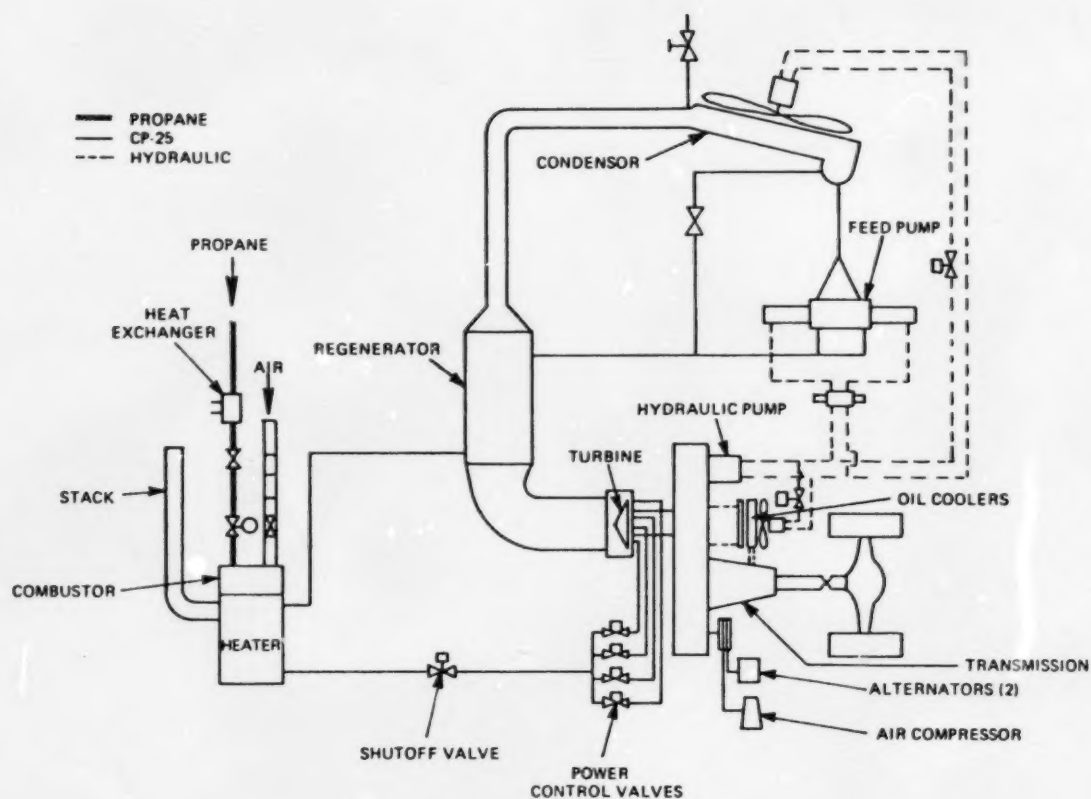
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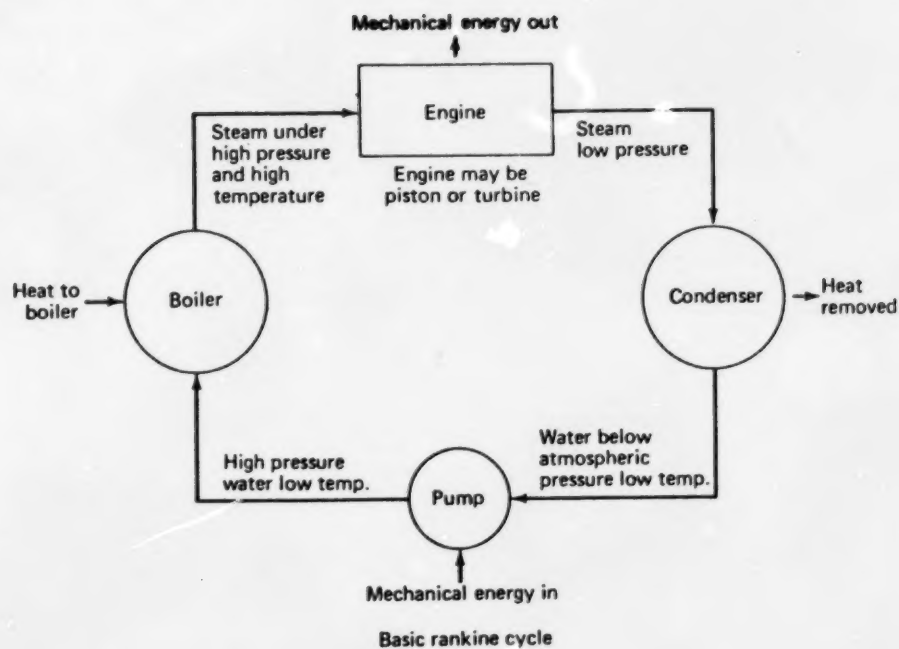


TERMO ELECTRON
RANKINE CYCLE ENGINE
SCHEMATIC DIAGRAM

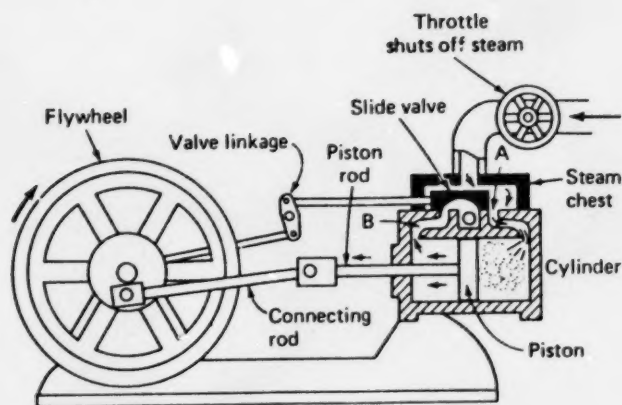
TECO Rankine-Cycle Engine
Schematic Diagram



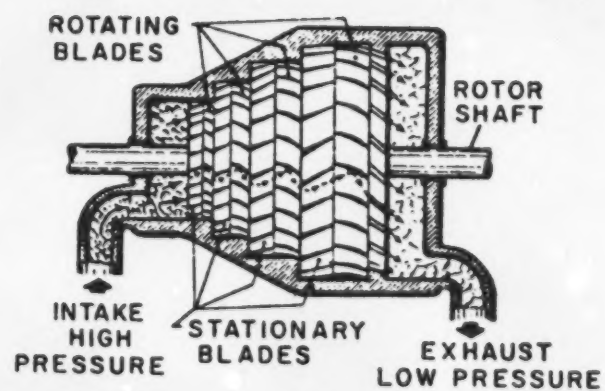
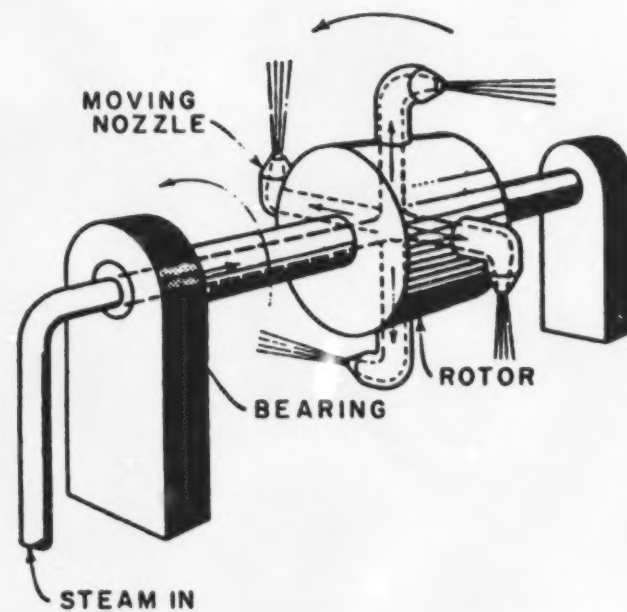
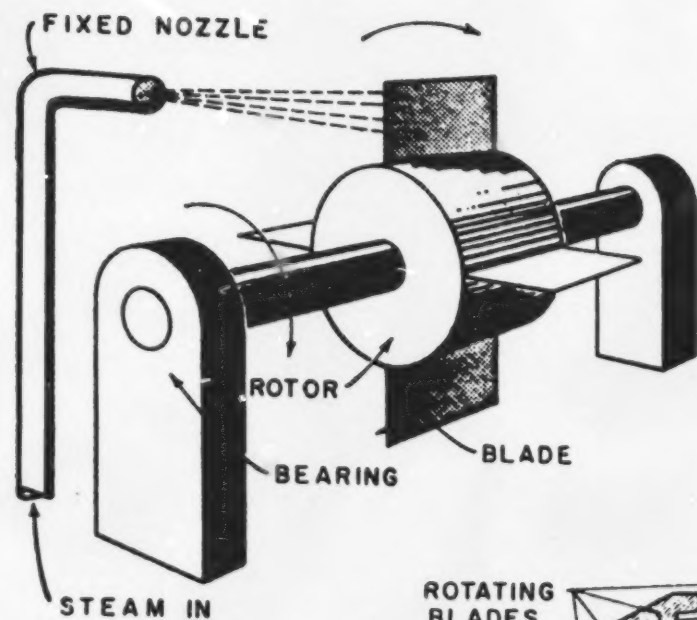
Arrangement of Sundstrand Organic Rankine Engine



The Rankine-cycle engine may use atomic power. It can operate in space.

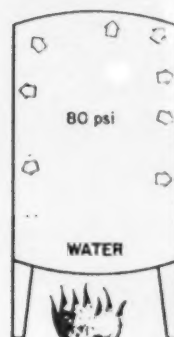


Cutaway view of a simple reciprocating steam engine.



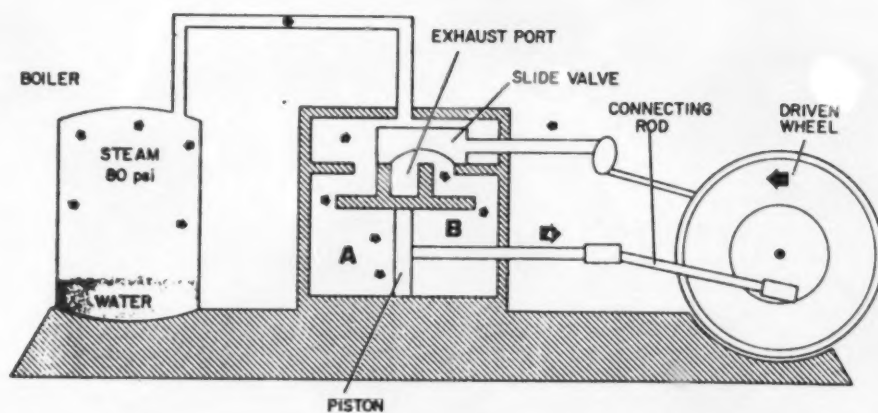
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Steam Heated in the Boiler Produces Pressure

This increased pressure is capable of producing a large amount of work.



The Steam Engine Converts the Force Produced by the High Pressure of the Steam into Usable and Controlled Motion

Student Activity #1

Making a Working Model of a Steam Turbine

Object The object of this activity is to demonstrate how a steam turbine converts heat energy into mechanical energy.

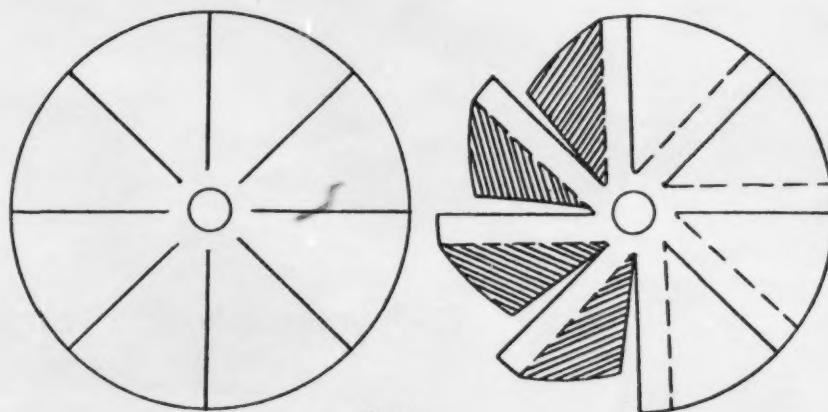
Equipment	medicine dropper	scissors
	test tube (attached to support rod)	pencil with eraser
	bunsen burner	manila circles
	stopper (one-hole)	ruler
	needle	compass
		thimble

Directions Make the turbine wheel first. Use the compass to draw a circle five inches in diameter in the manila folder. Use the same center for the compass, and draw a 1-inch diameter circle inside the larger circle. Place the thimble open-end down on the center of the circle you have drawn, and draw a third circle around the thimble.

Use the scissors to cut along the inside of this small circle, and insert the thimble into the hole. Use the ruler to draw eight lines to the inner circle so that you have a large circle divided into eight equal parts.

Cut along the lines to the drawn inner circle. Next bend half of each section back along the dotted lines in the diagram (see below). The paper halves should show right angles.

Insert the needle into the rubber eraser of a pencil. Place the paper turbine wheel over the tip of the thimble and set the inside of the thimble on top of the needle.



Operating the Turbine

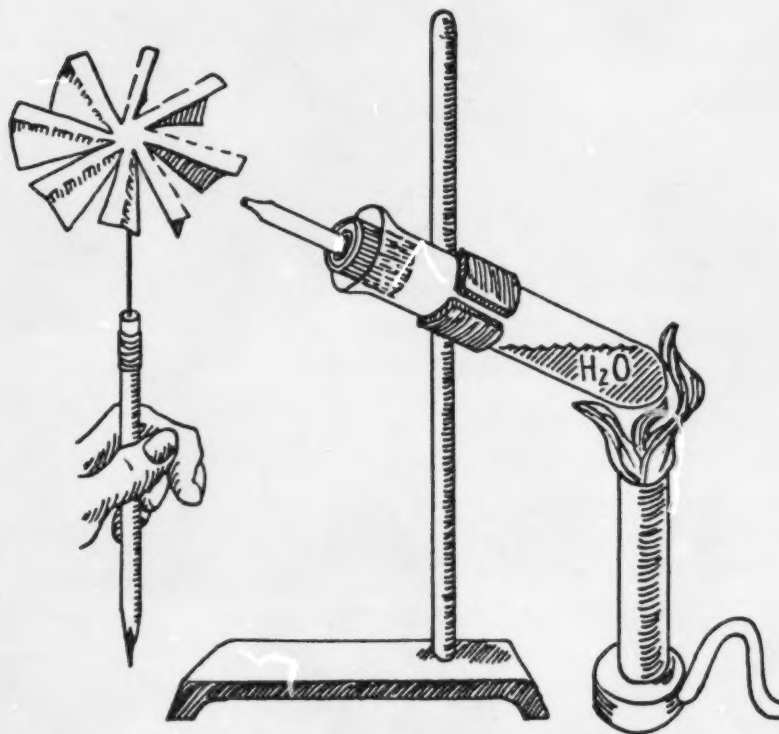
Put about 1 inch of water in a test tube and assemble the equipment as shown in the diagram below.

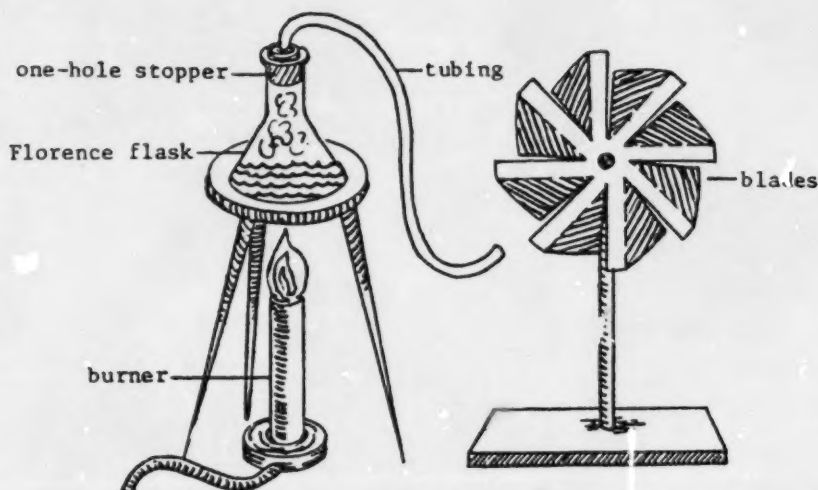
Remove the rubber bulb from the medicine dropper. Moisten the outside of the medicine dropper and insert it carefully through the one-hole stopper. Insert the stopper into the open end of the test tube, but don't push it in too tightly. Light the bunsen burner and heat the water in the test tube. Answer these questions:

1. What changes do you see?
2. Is energy involved in these changes? How?

Hold the pencil with the thimble top of the turbine attached in such a way that it turns freely, and direct the path of the steam against the paper blades of the turbine.

1. What is happening to the blades?
2. Can you explain why this is happening?
3. Is work being done? How?





Sum up by asking: Is this model an external or internal combustion engine? Tell how you know. Complete the following sentence by supplying the best word:

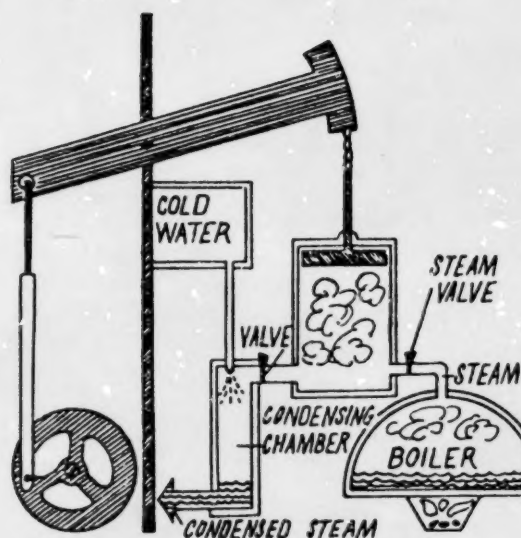
In this engine chemical energy in the fuel is converted to heat energy and then to mechanical energy.

Day 2 - You may encourage fuller understanding of the fact that all heat engines - no matter what their type is - convert heat energy to mechanical energy if you distribute the fact sheet about types of engines and what they do to fuel at this time. Have students complete the crossword combustion puzzle to culminate the lesson on heat engines.

You may prefer to provide a transition from the experiment to the summing-up part of the lesson by giving the students a drill exercise on the various engine terms. Distribute the word study list and allot sufficient time for the students to read it carefully. Then ask some questions such as the following:

1. What do we call a jet with no moving parts?
(Ramjet.)
2. What do we call a machine that changes another form of energy into mechanical energy?
(Engine.)
3. What kind of engine is it that burns fuel outside the engine.
(External combustion engine.)
4. What name is specifically given to an engine that converts heat energy into mechanical energy by the back and forth motion of a piston in a cylinder?
(Reciprocating engine.)

Watt's Steam Engine



TRY IT. Make a bulletin board cut-out model of Watt's engine. Use your model to show the engineering principle of Watt's engine.

Think of five changes that have occurred in our own lives that have been the result of the steam engine.

Research the modern steam engine, which uses a high pressure system to produce power. Compare the high pressure systems with Newcomen's, Savery's, and Watt's atmospheric engines.

EQUIPMENT/SUPPLIES

1. One tin can with closeable lid
2. One screw-eye
3. One swivel
4. Six inches copper tubing (1/4" diameter)
5. Solder
6. Soldering gun
7. One piece of string